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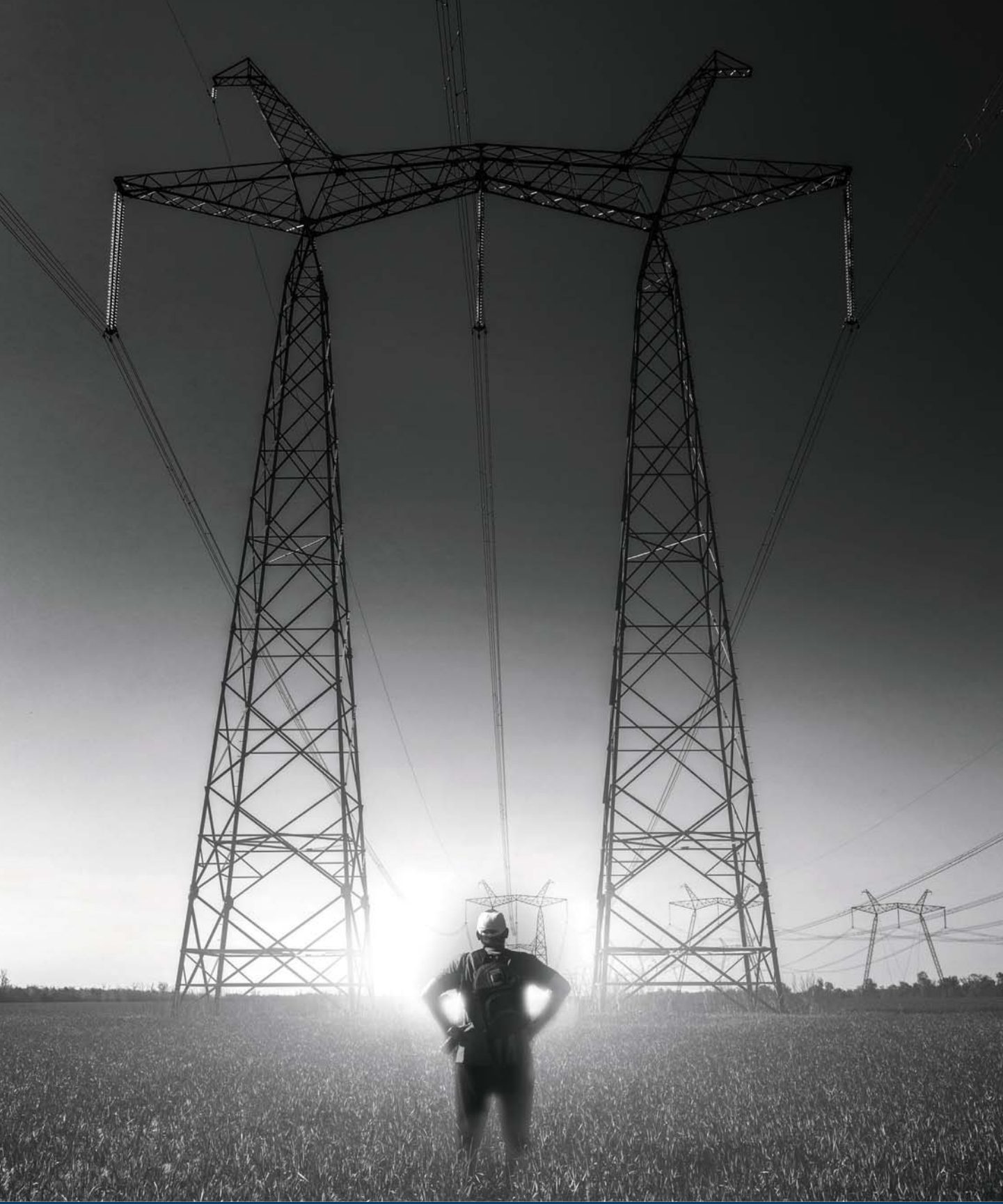

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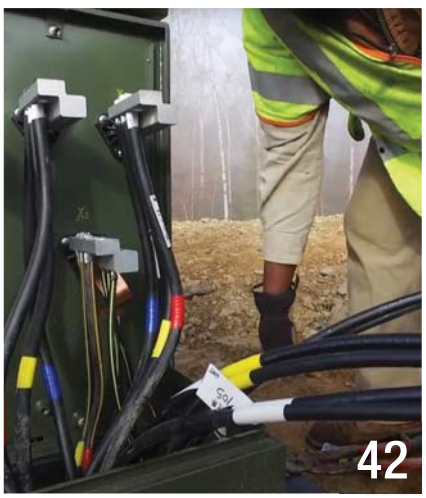

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COORDINADOR
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International Competitive Bidding

National Electric Transmission System of Chile.

Within the framework of the General Law of Electric Services of Chile, by the provisions of Decrees of New Works No. 257 of 2022 and No. 229 of 2021, and in Decrees of Expansion Works No. 200 of 2022 and No. 185 of 2021, all from the Ministry of Energy, the National Electrical Coordinator will call for an International Public Tender for the Award of the construction and execution of the following works of the Transmission System:

Project	VI Referential [MMUSD]
New S/E Sectioning Llullaillaco	21,93
New Flow Control System through storage Parinas – Lo Aguirre Panel Saw	211,16
New S/E Sectioning S/E El Pimiento	18,03
New S/E Monte Blanco and New S/E El Lazo	13,02
New 1x110 kV El Pimiento – Monte Blanco Line, New 1x110 kV El Pimiento – El Lazo Line and New 1x110 kV Monte Blanco – El Lazo	14,91
New S/E Sectioning Pachacama	9,82
New S/E Sectioning Linderos	16,33
New S/E Sectioning El Guindal	9,31
New S/E Litueche and New Line 2x110 kV Litueche – La Estrella	12,61
New Line 2x154 kV Fuentecilla – Malloa Nueva	16,86
New Line 2x154 kV Tinguiririca – Santa Cruz	27,87
New S/E Sectioning Las Delicias	16,46
New S/E Coiquén and New Line 2x66 kV Las Delicias - Coiquén	13,33
New S/E Sectioning La Invernada	7,52
New Line 1x66 kV Santa Elisa - Quilmo II	5,18

Project	VI Referential [MMUSD]
Expansion in S/E Parinas (NTR ATAT)	34,97
Expansion in S/E Parinas 500 kV (IM) And 220 kV (IM)	5,97
Capacity Increase Line 1x66 kV Buin – Linderos	2,17
Expansion at S/E The Star 110 kV (BS)	0,89
Expansion in S/E Fuentecilla 66 kV (BP+BT), New Yard 154 kV (NBPS+BT), New Transformer (NTR ATAT) and Sectioning Line 1x66 kV San Vicente de Tagua Tagua – Las Cabras	9,90
Expansion in S/E Malloa New 154 kV (BPS) and Sectioning of Line 1x154 Punta De Cortés – Tinguiririca	4,28
Expansion in S/E Tinguiririca 220 kV (IM) And 154 kV (BPS+BT)	5,22
Expansion in S/E Tinguiririca (NTR ATAT)	9,64
Expansion at S/E Santa Cruz 66 kV (BP+BT), New Yard 154 kV (NBPS+BT) and New Transformer (NTR ATAT)	8,36
Expansion at S/E San Fernando 154 kV (NBP+BT)	3,57
Laying of Second Circuit Line 2x154 kV Tinguiririca – San Fernando and Construction of Cloths in S/E San Fernando	3,68
Expansion in S/E Cellulose Pacific 220 kV (BS)	4,48
Expansion at S/E Quilmo II 66 kV (BS) and Sectioning of 1x66 kV Line Chillán – Tap Quilmo	2,03
Expansion at S/E Santa Elisa 66 kV (NBP+BT), New Transformer (ATMT) and Sectioning of Line 1x66 kV New Village – Santa Elvira	4,48

*The final list of completion of works will be confirmed during the bidding process.

To participate in this process, interested parties can acquire the Bidding Bases corresponding to the Call, which will be available from the second half of March 2023, and request registration in the Register of Participants in the manner indicated in the Bases above through the Website: **https://www.coordinador.cl/desarrollo/documentos/licitaciones/nuevas/2023-obras-nuevas-decreto-n-257/**. These Bidding Bases will be available free of charge at the link to the Website.

Legal entities, both Chilean and foreign, may acquire the Bases and register in the Register of Participants, who may participate individually or as part of a consortium or association, complying with the demands and requirements established in the General Law of Electric Services and in the Bidding Bases.

National Electrical Coordinator

Extremists and Fools Threaten Energy Infrastructure

I'm pretty sure I could fill this column each month writing about a recent widespread outage caused by the latest significant weather event. During most any week of the year, it's typical for some part of the U.S. to be impacted by extreme weather. Electric utilities expect and, for the most part, understand their weather-related risks. They, along with many solution providers, work diligently to harden their grids and make them less vulnerable to these risks.

Of course, weather events are just one of the risks electric utilities and grid operators experience. According to PwC's 25th Annual Global CEO Survey released in 2022, 44% of energy and utility CEOs ranked cyberthreats among their top three concerns. Utility industry executives have been talking about the dangers associated with repeated cyberattacks for years. Utilities are working with each other as well as with many outside agencies and technology providers to stay ahead of hackers and cyber terrorists. To get a better read on the significance of cyberthreats, the Cyber Incident Reporting for Critical Infrastructure Act of 2022 (housed within the Consolidated Appropriations Act of 2022) was signed into law by President Biden in March 2022. The Act requires energy companies, including electric utilities, to report and share certain information related to cyberattacks. This is a step that many experts say was overdue.

Physical attacks to the grid also are a real threat and seem to be on the rise. As I'm writing this column, reports are circulating about a near physical attack to multiple Baltimore Gas & Electric substations. The FBI uncovered the planned attack and arrested two individuals whom they called "racially or ethnically motivated" extremists. The duo intended to create a "cascading failure" that would cause major damage and take BG&E months to repair and rebuild. Their plan was to simultaneously shoot critical equipment in multiple electric substations around Baltimore to maximize the attack's impact. The FBI made it clear that the two suspects were not simply talking about the attack, but were taking steps to carry it out.

This report of a thwarted physical attack is the latest in a string of substation attacks carried out in the past few months. Since November, there have been reports of substation attacks in Oregon, Washington State and North Carolina. While power was not interrupted in Oregon, outages did occur in Washington and North Carolina.

These types of attacks aren't isolated to only electricity infrastructure. A man from Fort Worth, Texas, recently was sentenced to five years in prison for attempting to blow up part of the Permian Highway Pipeline near Austin in January 2022. His plan failed, and he turned himself in. According to U.S. Department of Justice records, the attack was motivated by his ideological fight against capitalism and climate change. He'd hoped to weaken Texas energy independence and negatively impact the economy.

Unfortunately, much like cyberattacks, not all physical attacks are made public, so energy infrastructure is likely more vulnerable than most of us know. According to the federal government, these types of attacks are happening more frequently. The National Terrorism Advisory System Bulletin issued by Homeland Security in June 2022, reveals that U.S. infrastructure is in a heightened threat environment. The bulletin says: "Threat actors have recently mobilized to violence due to factors such as personal grievances, reactions to current events, and adherence to violent extremist ideologies, including racially or ethnically motivated or anti-government/anti-authority violent extremism. Foreign adversaries — including terrorist organizations and nation state adversaries — also remain intent on exploiting the threat environment to promote or inspire violence, sow discord, or undermine U.S. democratic institutions." As the presidential election gets closer (the first primary is only 11 months away), many security experts, including Homeland Security, believe we'll see greater threats from domestic violent extremists.

Not all attacks, however, are motivated by personal grievances or extremism. The two men who vandalized substations in Washington, interrupting power to 14,000 customers on Christmas day, weren't terrorists or politically motivated. Federal agents revealed the pair knocked out power so they could burglarize a local business, emptying its cash register while the power was out.

There were more than 55,000 substations in the U.S. in 2020, per the Department of Energy's Office of Electricity, and I suspect that number has grown since then. In addition, there are 200,000 miles of transmission lines and nearly 6 million miles of distribution lines in the U.S. Most of the lines and the equipment attached to them are above ground and easily accessible to someone intending to cause harm. Nearly all substations are fenced and some of the larger, high-voltage substations are equipped with alarms and video surveillance, but few have bullet proof equipment or shielding to protect them from gun attacks. In addition, many are in remote areas, so even with alarms and video surveillance, it's difficult for utilities or other authorities to stop an attack if alerted. Bulletproof shielding and equipment could help, but many substations are large, which means making them bulletproof would be costly. Undergrounding equipment can add protection, but again it is expensive. For a utility's investment to make sense and gain approval from boards of directors and regulators, undergrounding usually must provide benefits in addition to physical security.

Protecting infrastructure from extreme weather events is difficult. Protecting it from both cyber and physical threats is just as hard, possibly more unpredictable, and infuriating. Who would have thought that two local fools would decide to vandalize several substations and disrupt power on Christmas day so they could steal money from a small business' cash register? How could that have been lucrative? Who uses cash these days anyway? TDW

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The Energy Transition Sky is Not Falling

The scene around Davos, Switzerland in January for the World Economic Forum was much hand-wringing, head-bowing, second-guessing, fretting and even RIPs for the progressive trifecta of energy transition, globalization and the ESG (environmental, social and governance) promises of Corporate Earth.

Economic crises, the pandemic and the war in Ukraine have changed everything, the harshest critics say. The energy transition is a pipe dream and ESG is dead.

Well, to paraphrase Mark Twain, the reports of that demise are greatly exaggerated, the CEO of data-energy technology firm GridBeyond said in an exclusive interview with *EnergyTech.*

The war in Ukraine has driven natural gas supply constraints and price hikes in a Europe dependent on Russian natural gas, but if anything that may actually accelerate the move to renewables and oather carbon-free resources rather than inhibit it, GridBeyond CEO and co-founder Michael Phelan predicted.

"The nations that are closer to the cold face of that particular war, this has definitely caused them to reconsider gas as a transitionary fuel (moving from coal power to natural gas as a compromise to lower emissions until renewables gain complete scale)," Phelan said. "They will try to transition at a faster rate to other resources. People in Europe, more so than the U.S., are kind of questioning whether the transition should go quicker."

Some might say it's already on an accelerated timetable, with nations such as the United Kingdom, Germany and France promising to reach Net Zero carbon emissions from energy by 2050 or even earlier. It's complicated by the fact that, even as they retire all coal-fired power, Germany and France are also moving away from carbon-free nuclear power.

This leaves some big supply gaps if most sectors of the economy are rushing toward electrification.

GridBeyond has just released an in-depth report, "Global Energy Trends 2023: Crisis, Contingencies and Climate Change." The company talked to various industry respondents and its own experts to offer some reflections on where the world is right now and a rosy picture of where it could be within decades...Hopefully.

"This means we could be on the brink of a historic turning point toward a cleaner and more secure energy future," Phelan wrote in the foreword of the GridBeyond report. "But it is important to remember that time is ticking, and this decade is our chance to stand up and play our part in creating a net-zero future that ensures supplies are available at a price that is affordable for all consumers."

Indeed, the coming energy transition may need an overbuild of carbon-free resources to achieve these goals at a price acceptable to most. Phelan sees an expansion of installed capacity in utility-scale wind, solar PV, battery storage and also hydrogen as pivotal to offering diversity and the required emissions reduction attributes.

"We're going to make the case for batteries today, for grid stability" and, eventually, economic efficiency, he added. "Batteries with solar might win today (but) hydrogen will take some time, maybe negative prices. We probably need an overbuild of hydrogen."

Wind will work in places of tremendous meteorological volatility, such as Texas, middle America and Ireland, Phelan noted. Too much is not enough when it comes to balancing an intermittent resource with enhanced demand as complete electrification of the economy gains momentum.

One resource gaining attention lately for its baseload, zero-carbon power is nuclear energy. U.S. utility Georgia Power is slowly completing the Vogtle Units 3 and 4 reactors expansion, and EDF is working to finish the Sizewell expansion in the UK.

And early adopters are expressing optimism for small modular reactor technologies. Nuclear fusion has made a breakthrough with experiments at the Lawrence Livermore National Lab in California, but reactive nuclear fission still rules the day when it comes to power generation.

Despite this recent promise of a nuclear revival, GridBeyond's Phelan doesn't see it making much of an economically beneficial case for companies and energy planners of the future.

"When you look at the overall economics they probably don't like what they see," said Phelan, noting the intensely high upfront cost per MWh of proposed new nuclear power plants.. "And it's not such a great answer in the short run, either. The economics aren't as good."

What looks good from current trends is that change has to happen no matter how it's built out.

"There's a good deal of thermal power plant retirements in the U.S. and Europe, and it has to happen anyway," Phelan pointed out. "Look, we have to replace the plants...is it a better business case to build out CHP or solar?"

What looks attractive, from a logistical point of view, is combining renewables and storage with next-gen digital tools such as artificial intelligence, machine learning, demand response and control systems, the GridBeyond CEO added. This is where the rubber meets the road to net zero.

"We're probably at a transition going from central control and command to much more of a decentralized and information system," Phelan said. "The supply side is going to be intermittent, so the demand side needs to flexible. . . How do I keep the system going and store energy. We're seeing this up close in a lot of markets. People are starting to think about what really happens with a supply that is intermittent, and demand is flexible." TDW

ROD WALTON is senior editor at *EnergyTech, T&D World's* sister brand that covers commercial and industrial markets and how they can better navigate the energy transition and meet aggressive carbon neutrality targets.

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Exponentially Challenged

It's no secret that I'm a techno-junkie, but a lesser-known fact is that I'm also a bookworm. And sometimes the stars align, providing me with not only some interesting technology, but also a book with some insights into a state-of-the-art technology or the human's interaction with the gadget. That is exactly what happened recently when Santa brought me a copy Neil deGrasse Tyson's latest literary work, *Starry Messenger: Cosmic Perspectives on Civilization*.

Dr. Tyson's book offered some interesting opinions about why we (humans) have such a hard time dealing with change. Personally I can't think of anything more change-inducing than technological advancements, which is especially true when it comes to the power delivery system. Smart grid technologies have been described as transformational, evolutionary, game-changing, and many more, but none of it happened without a great deal of pushback from stakeholders.

Tyson explained the resistance was due to humans being "wired" to think linearly (i.e., "additives and multiples"), but changes often happen exponentially ("number raised to the power of another number"). After some contemplation I started thinking about it in terms of being exponentially challenged when it comes to technology.

Most of us would rather follow a sequential trail of developmental breadcrumbs, but I can't think of any radical innovations that happened that way. Unfortunately, when it comes to cutting-edge improvements they tend to be more like quantum leaps than continual improvements.

Technological Pushback

Many years ago I was designing substations using AutoCAD. The technology improved to the point it was easy to design a substation in 3D (three dimensions) for those who thought spatially. My team and I were really excited about it. We came up with a complete 3D drawing package, but when it was presented there was significant pushback from all levels of engineering.

The client's manager and his staff could not figure out what they were looking at. My team and I were sent back to the office to redraw the station using traditional methods (i.e., section and elevation views). That wasn't a big deal with this technology, a few clicks on the menu and AutoCAD produced the desired drawing package. A funny side note of this story happened a few months later when we started the construction phase.

I met with the construction foreman and his staff. They had reviewed the drawing package and had a suggestion. They had been working in California with utilities who produced all their construction drawings in 3D, which provided more detail and were easier to follow. I walked back to my truck and brought them my 3D set. Nowadays 3D drawings are commonplace, and have morphed into virtual representations of the power grid, but it was rough going initially.

iStock/Getty Images Plus

Yesterday vs. Today

My 3D adventure was a long time ago, but exponential challenges have no shelf life. Recently a FERC (Federal Energy Regulatory Commission) message crossed my virtual desk. FERC's Order No. 881 has been getting some attention and FERC had comments. The order addresses increasing the capacity of the nation's transmission system using ambient-adjusted rating methods like dynamic line rating (DLR) technology.

Back when transmission technology was developing, a group of experts formed to create a safe method of determining the maximum transfer capacity of a transmission line. Not having the benefit of modern sensors, they authored a series of conservative tables based on assumptions. Amazingly this old-school system is still used today. Over the years, there have been efforts to modernize the tables, but that only resulted in generating assumption-based seasonally adjusted tables.

DLR systems on the other hand have actually increased existing transmission lines' maximum transfer capability anywhere from 10% to 25% or more than what they were designed for using the tables. DLR takes advantage real-time data combined with line behavioral modeling. The technology, however, is one of those exponential changes we started off with in this discussion.

Telling someone they can increase the capacity of a transmission line by 25% because of a new technological application has proven to be hard to accept. After all, it doesn't involve any physical changes to the transmission line. It only requires the addition of some sensors and transducers feeding data into a computer. Still a 25% increase in capacity can no longer be ignored.

This is especially true today when there over 1,400 gigawatts of renewable energy projects currently in connection queues vying for the grid's limited transmission capacity. Let's get comfortable with technology's quantum leap capabilities; we need them! TDW

COORDINADOR
ELÉCTRICO NACIONAL

International Public Bidding
for the Award of the Complementary Service of Voltage Control by Short Circuit Power Contributions.

Within the framework of the provisions of the General Law of Electric Services of Chile, and in accordance with the provisions of Decree No. 113 of 2017 of the Ministry of Energy, published in March 2019, which approves the Regulation of Complementary Services referred to in Article 72°-7 of the General Law of Electrical Services, and other regulations applicable to Complementary Services, the National Electrical Coordinator will make the call for International Public Bidding for the Award of the Complementary Service of Voltage Control for Short Circuit Power Contributions.

In order to start the bidding process, and complying with the legal requirements of the aforementioned Decree No. 113 of 2017, the National Electric Coordinator published the Complementary Services Report for 2023, in which the main considerations of this bidding process are presented. The document is available at the following link:

Link: **https://www.coordinador.cl/operacion/documentos/servicios-complementarios/isscc/ano-2023/**

It should be noted that this tender considers the construction and operation of new infrastructure of complementary services through two (2) technical solution alternatives to cover the voltage control requirements established in the Coordinator's Complementary Services Report for the year 2023: the first, corresponds to the installation of Synchronous Capacitors, and the second, corresponds to the Conversion of existing generation facilities.

To participate in this process, interested parties can acquire the Bidding Rules corresponding to the Call, which will be available from the second half of March 2023, and request registration in the Register of Participants, in the manner indicated in the aforementioned Bases, through the website: **https://www.coordinador.cl/desarrollo/documentos/licitaciones/servicios-complementarios-ct/** . These Bidding Rules will be available free of charge at the link to the Website.

It should be noted that legal entities, both Chilean and foreign, may be registered in the Register of Participants, who may participate individually or as part of a consortium, complying with the requirements and requirements established in the General Law of Electric Services, Decree No. 113 of 2017 and other regulations applicable to complementary services, as well as the provisions of the Bidding Rules, as appropriate.

National Electrical Coordinator

VPPs: Bring Your Own DERs

Thinking outside the grid is upgrading the infrastructure in a different way.

It's been over a year since "Charging Ahead" featured virtual power plant (VPP) technologies, but recently VPPs have been back in the news as the use of these devices becomes more widespread. It's not only widespread, it's changing how we think about electricity generation. It could be said that VPPs are causing stakeholders to think outside the grid. VPPs are moving energy production from centralized generating plants to a variety of dispersed energy sources located behind-the-meter (BTM).

The VPP technology makes it possible to harness thousands of distributed energy resources and makes them perform like a single generating source. © Luisfilipemoreira | Dreamstime.com.

The VPP technology makes it possible to harness thousands of distributed energy resources (DERs) and makes them perform like a single generating source. That, however, isn't what has struck a chord with the public. What is resonating within the customer-base is a continuous revenue stream in the face of rising electric bills. Also hitting home is the ability to power homes and businesses when the grid is out for whatever the reason. It hasn't hurt that the technology has become more user friendly making VPPs attractive to customers, utilities, grid operators, and regulators.

There have also been a wide-ranging assortment of outside influences that have impressed individuals with the flexibility of VPP applications. At the start of the 2022-2023 winter storm season, you may remember researchers had predicted that it would be a mild winter with higher temperatures and less demand to electricity. In reality, global climate change seems to have provided a recurring phenomenal sequence of "once-in-a-lifetime" storms that has impacted the power system's ability to deliver electricity. As a result, there has been an increase in interest in nontraditional technologies like VPPs utilizing BTM-DERs for keeping the lights on.

Thinking Outside the Grid

One of these nontraditional VPP BTM-DER applications uses the vehicle-to-grid (V2G) and vehicle-to-load (V2L) technology's bidirectional EV (electric vehicle) batteries and chargers. Utilities and EV manufacturers joined together and developed several VPP demonstration projects utilizing V2G/V2L technology as a power supply. The projects were successful and has become a sustainable energy storage resource. It recently got a shot in the arm when some new partnerships were publicized.

PG&E (Pacific Gas & Electric) and Ford announced their partnership to power homes using Ford's F-150 Lightning eTrucks. In addition, Duke Energy and Ford also announced a similar partnership. In both programs, the F-150 eTrucks will supply homes with power in the event of an outage and return power to the grid when support is needed. Ford calls it "intelligent backup power."

Hyundai launched its "Hyundai Home" application a few months ago. It's designed to give consumers an easy way to "produce, store, and use their own energy to power their lives at home and on the road." Hyundai went on to say customers can "make their homes more resilient with solar panels, energy storage systems and EV chargers."

Another EV powered VPP was announced by Oncor and Toyota. It's a research project using Toyota customers' V2G/V2L technology to power the VPP. According to Toyota, their customers can use their EVs to power their homes and their communities. In times of need the EV powered VPP will feed power back into the power gird.

The most trendy DER are the popular rooftop solar assets that experts refer to as "a huge untapped source of electricity." The California Public Utilities Commissions estimates that the state's distributed solar represents about 12 gigawatts (GW). It does, however, need energy storage to make it sustainable for VPP applications. Subsequently there is a thriving market in place to upgrade those systems into solar-plus-storage DERs.

If that isn't enough, these DERs can be modified to turn them into microgrids or nanogrids depending on capacity of the DERs. These upgrades are available from many suppliers such as Eaton, Schneider Electric, Hitachi Energy, GE, Siemens Energy, to name a few. Remarkably some naysayers don't believe there's enough interest in the technology to do what developers claim. So, let's see how seriously the industry is taking VPP technology.

Several research companies have looked into this specialized market segment. The most recent investigation comes from Prescient&Strategic Intelligence. They published a

report in December based on the historical years of 2017-2022. The global VPP market was valued at about US$3.4 billion in 2022. It's expected that the VPP market size will grow to around US$12.3 billion by 2030, which is a CAGR (compound annual growth rate) of 16.9% for that period. This is a good point to dig a little deeper into the capabilities of VPP applications.

Is the Technology Effective

Critics argue that solar-plus-storage DERs are not sufficient to energize a home or business long enough to be effective during a prolonged outage. It a troubling issue for customers about to spend a lot of money on a system. A report published by the Lawrence Berkeley National Laboratory (LBNL) addressed this topic.

The report is a collaboration between LBNL, and the National Renewable Energy Laboratory titled, "Evaluating the Capabilities of Behind-the-Meter Solar-Plus-Storage for Providing Backup Power during Long-Duration Power Interruptions." It focuses on how successful rooftop solar-plus-storage systems are when it comes to keeping the lights on for 3 days or more.

The study looked at a group of 10 historical long-duration power outage events over a wide range of geographies and evaluated how solar-plus-storage systems performed. The study limited the critical load scenario excluding heating and cooling. It found a small solar-plus-storage system with 10 kWh (kilowatt hour) of storage can fully meet backup needs over a 3-day outage in virtually all U.S. counties and any month of the year. The size of the load can be increased, but the capacity of the installation also has to be increased. If you would like to read the report, it can be downloaded at *https://emp.lbl.gov/publications/evaluating-capabilities-behind-meter.*

Merging Prosumagers

Solar-plus-storage is not only effective, it has the ability to move the owner into the prosumage category, which is a key element in the growth of VPP applications. Prosumage comes from the combination of producer (pro) plus consumer (sum) plus storage (age). Aggregating prosumagers together with a single centralized BTM-DER control system forms a VPP, and it's all off-the-shelf technology. For that reason, there is a growing list of utilities partnering with third party aggregators resulting in VPPs powering the grid.

One such program was announced by Sacramento Municipal Utility District (SMUD). Their offering is called the "My Energy Optimizer Partner+" program. It's a residential customer-driven VPP that plans to start operations in April of this year. The VPP has about 600 customer-sited energy storage systems and roughly 400 in the interconnection process. Swell Energy will manage the VPP for SMUD. The targeted size of the VPP is 54MWh/27MW. For more details see *https://tdworld.com/21256886.*

Another is "Project Symphony," a VPP that went online in Perth, Western Australia last year. It's a two-year project conducted by the state-owned network provider Western Power, utility company Synergy, and the Australian Energy market Operator. More than 300 customers and 650 customer-owned DERs are taking part in the VPP. The target is to have 900 business and home DERS aggregated to produce electricity for grid consumption.

Another EV powered VPP was announced by Oncor and Toyota. It's a research project using Toyota customers' V2G/V2L technology to power the VPP. Toyota USA.

The Public Utility Commission of Texas has been making news with their "ADER" (aggregated distribution energy resource) project when it was approved by ERCOT (Electric Reliability Council of Texas) for the grid. ADER will allow customers with generation, energy storage and/or controllable loads with a capacity of 1 megawatt (MW) or less participate in the ERCOT wholesale markets. The initial phase of ADER is limited to 80 MW with no more than 40 MW allocated to non-spinning reserve services.

With the ADER project approved, Tesla announced they have launched a Texas-wide VPP project by inviting Powerwall owners to take part. This will be much like the VPP pilot program PG&E and Tesla introduced in northern California in 2021. That project was successful and in 2022 it was expanded into southern California through a partnership with SCE (Southern California Edison).

Bring Your Own Battery

It's interesting, customers have embraced rooftop solar by installing GWs of solar generation. As prolonged power outages happened, they added batteries to their BTM-DER installations. Some reporters dubbed them "bring-your-own-battery" applications, but more accurately they are actually a "bring-your-own-DER" application. EV's are also coming to the party with their batteries adding V2Gs to VPPs.

Government support has been strong with tax incentives for customers installing both solar and solar-plus-storage systems. It has also opened regional organized wholesale marketplaces to aggregators providing power and ancillary services. Granted, all of these DER aps are still in the process of evolving, and all of them are made up off-the-shelf technologies that are readily available.

Combining them into VPPs is becoming easier everyday as proven by the numbers of utilities and grid operators adopting them as grid resources. A clear indication of this is an announce from Swell Energy that they had raised US$120 million to expand their deployment of VPPs. This is a ambitious undertaking; it's going to be fun to watch! TDW

QUANTA SERVICES SELECTED FOR COLORADO'S POWER PATHWAY

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Quanta Services, Inc. has been selected by Xcel Energy as its prime constructor to manage all construction activities for the Colorado's Power Pathway high-voltage electric transmission project in Colorado. Quanta's scope of work on the project consists of the construction of approximately 610 miles of 345 kV transmission infrastructure, consisting of up to six segments and spanning more than a dozen counties, primarily in eastern Colorado, and includes the installation of four new substations and the expansion of four existing substations.

The project is designed to increase the reliability of the state's power grid and enable future renewable energy development in Colorado, including approximately 5500 MW of new wind, solar and other resources that Xcel Energy plans to add through 2030.

"Quanta has enjoyed a long-standing relationship with Xcel Energy and this project builds on our partnership. The project represents an innovative model and collaborative approach with Xcel Energy that we believe is a ground-breaking path for Quanta to continue to provide collaborative infrastructure solutions to our customers. As a result, we believe our design and constructability plan enhances safety during construction and positions us to provide schedule, quality and cost certainty for this important project." said Duke Austin, president and CEO, Quanta Services.

"We are excited to move forward with Quanta Services on the Colorado's Power Pathway project, a monumental investment to build reliability in our transmission system and enable access to significant renewable energy resources in Colorado," said Robert Kenney, president of Xcel Energy-Colorado. "We look forward to collaborating with Quanta as we advance this critical project."

Certain segments of the project are expected to be completed in 2025, with other segments expected to be completed in 2026 and 2027. Preconstruction activities are expected to begin immediately, with construction on the first segment scheduled to begin in mid-2023. Quanta expects to include the estimated revenue for the project in the remaining performance obligations and backlog associated with its Renewable Energy Infrastructure Solutions segment for the fourth quarter of 2022. *—T&D World Staff*

FPL PRESIDENT TO STEP DOWN

The longtime leader of Florida Power & Light Co. said Jan. 25 he will retire from the utility and its parent company, NextEra Energy Inc., in May and would step into a transitional role.

Eric Silagy has been president of FPL since late 2011, was named CEO in May 2014 and added the chairman title to his business card nearly a year ago. As part of the 57-year-old's decision to step down, the NextEra board has agreed to pay Silagy his 2022 incentive payments as well as a portion of his stock and option awards in return for him releasing possible claims against the company and committing to two-year non-compete and non-solicitation agreements.

Stepping into Silagy's seat will be Armando Pimentel Jr., the former head of NextEra Energy Resources, the company's clean-energy projects developer and operator, as well as NextEra's CFO from mid-2008 to the fall of 2011.

Silagy's pending departure comes after the politically connected executive — he has, among other things, helped the Florida Chamber of Commerce, the State University System of Florida and the Florida Council of 100, which advises the state's governor — and FPL were shown to have worked with political consultants, with reports saying the company had paid more than $10 million to dark-money groups looking to sway Florida elections and news coverage.

Speaking to analysts on a conference call discussing NextEra's fourth-quarter earnings, Silagy said he didn't have a firm timeline to step down but had told NextEra Chairman, President and CEO John Ketchum in early 2022 he was committed for at least a year.

"This is the kind of job that you have to plan ahead and we're getting ready to go in another rate case cycle," Silagy said. "That's a multi-year type of approach. And so to go forward longer means I'm really committing through 2026."

Both Silagy and Ketchum acknowledged that 2022 was a challenging year for FPL, which in addition to the campaign-finance

scrutiny also had to handle two hurricanes and wrestle with inflation and supply chain pressures. But when asked whether there is a link between Silagy's planned exit and a possible Federal Election Commission investigation, Ketchum said his team is "not making a connection."

The FEC claims against FPL, Ketchum outlined, involve at most $1.3 million in contributions. He added that he doesn't think FPL would be held liable for a separate set of allegations under Florida law and noted that the FEC has up to 18 months to decide whether to launch a formal inquiry.

"We think that a claim like this, that's based solely on media reports and allegations, is not the type of a claim the FEC should take up," Ketchum said. "We do not believe that the federal allegations, taken as a whole, would have a material impact on our business."

Despite those explanations, investors were skeptical about the risk to NextEra. Shares of the company fell nearly 9% Jan. 25 to $76.59 on trading volume of more than four times their daily average. The drop took NextEra's stock below where it was trading six months ago.

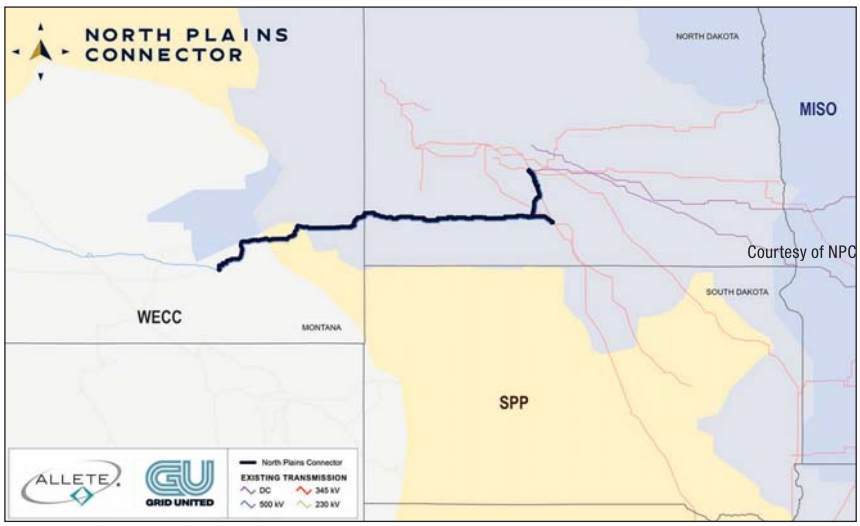
The Silagy news overshadowed NextEra's Q4 numbers, which showed a profit of more than $1.5 billion on revenues of nearly $6.2 billion, increases from $1.2 billion and $5.0 billion, respectively, in late 2021. FPL's bottom line grew to $763 million during the quarter versus $620 million the prior year thanks in part to 1.3% growth in its customer count and business mix. At NextEra Energy Resources, profits climbed to $996 million from $851 million in the last three months of 2021.

Ketchum and his team are upbeat about their ability to add to that growth. They have extended their main financial targets by a year through the end of 2026 and said passage of the Inflation Reduction Act has given them much better visibility into growth beyond that. Their expectations for NextEra Energy Resources development of wind, solar and storage projects through the end of 2026 now stand at between 32.7 GW and 41.8 GW.

For context, Ketchum pointed out the FPL's total generation capacity totals 27 GW and that merely hitting the bottom end of the 2026 range would more than double NextEra's portfolio, which took more than two decades to build out. — *Geert de Lombaerde*

NEW HVDC TRANSMISSION LINE FROM NORTH DAKOTA TO MONTANA ANNOUNCED

ALLETE, Inc. and Grid United intend to jointly develop the North Plains Connector, a new, approximately 385-mile high-voltage direct-current (HVDC) transmission line from central North Dakota to Colstrip, Montana. The North Plains Connector HVDC line will be the nation's first transmission connection between three regional U.S. electric energy markets—the Midcontinent Independent System Operator, the Western Interconnection and the Southwest Power Pool. This new link, open to all sources of electric generation, would create 3,000 MW of transfer capacity between the middle of the country and all three energy markets, easing congestion on the transmission system.



ALLETE and Grid United have signed a memorandum of understanding to explore transmission opportunities, with plans to execute a North Plains Connector development agreement in the first half of the year. The project represents an approximately $2.5 billion investment in Montana and North Dakota and will be a long-term asset for those states. ALLETE expects to pursue at least 35% ownership and would oversee the line's operation.

The North Plains Connector project is in the development phase, with Grid United engaging with landowners and stakeholders to determine the best route for the line. The companies expect project permitting to start this year as they work toward an in-service date of 2029, pending regulatory approvals. —*T&D World Staff*

DOE OPENS CALL FOR DEPLOYABLE SOLUTIONS TO SECURE AMERICA'S POWER GRID

The U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) have announced a call for applications for the second cohort of the Clean Energy Cybersecurity Accelerator (CECA) program.

The program brings together federal experts, energy industry representatives, and innovators in a unified effort to rapidly develop cybersecurity solutions for renewable energy resources and other grid operations and to bring them to market faster. CECA is a key component of DOE's strategy to ensure America's critical energy infrastructure remains reliable, resilient, and secure as more renewable energy is incorporated into the generation mix to achieve President Biden's ambitious vision of a 100% clean electricity sector by 2035 and net-zero economy by 2050.

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"As physical and virtual threats to our critical energy infrastructure continue to evolve, DOE is using all the tools at our disposal to lock down cybersecurity vulnerabilities of today and tomorrow," said U.S. Secretary of Energy Jennifer M. Granholm. "By supporting new, innovative technologies, the CECA program will help bring cutting-edge solutions to market more rapidly—ensuring our nation's electric grid is secure and reliable as it transitions to 100% clean energy."

For its second cohort, CECA seeks applicants with solutions that actively identify all industrial control system assets connected to a utility's infrastructure, both physically and virtually, to understand the totality of assets that need to be monitored and protected within the environment. The solutions should support the identification of unauthorized, unmanaged, or compromised assets to be removed or remediated. During a period of three to 12 months, cohort participants will receive professional evaluations of their technologies and partnership opportunities while developing and evaluating cyber-risk solutions in a collaborative setting.

As part of the CECA program, DOE and NREL have partnered with Berkshire Hathaway Energy, Duke Energy, and Xcel Energy in a joint effort to tackle the growing cyber threats to the U.S. energy sector, and other utilities are invited to join. The partnering utilities may use the cohort's cybersecurity technologies once they are assessed and validated and will also gain insights from the technology developers on the latest cyber challenges, best practices, trends, and the ability to understand cyber technology solutions.

In December 2022, DOE and NREL announced the CECA program's first cohort—three participants with cyber-defense technologies unproven in energy systems to authenticate distributed energy resources. The three participants have recently started a technical assessment of their technologies and will have the opportunity to showcase their solutions using NREL's world-class laboratory facilities. — *T&D World Staff* ■

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The female eagle tended her egg until the last possible moment as the crew approached to trim hazardous sticks from the nest. Photo courtesy of David R. Smith, Coastal Resources, Inc.

Protecting Power Lines and Birds of Prey

A breeding pair of bald eagles moved into a lattice transmission tower and engineers moved to protect a raptor family and power lines from each other.

By **DUNCAN ECCLESTON** and **LIBBY MOJICA**, EDM International, Inc.; and **CRISTINA FRANK** and **BENJAMIN S. JESSUP**, Pepco Holdings

On a chilly February morning in 2021, a phase-to-ground trip was initiated near the banks of the lower Potomac River in southern Maryland. The substation breakers quickly restored the 230kV transmission line to full operation; however, the connecting stations service large critical customers, where any power interruption would be unwelcomed.

Pepco field investigators quickly tracked the fault to the 908E lattice tower, where wet sticks from an untidy nest dangled precariously above the center phase. The ongoing threat to reliability was indisputable, and the culprits were bald eagles. With their unkempt nests and heedless defecation habits, it is difficult to reconcile the sublime majesty of our national bird with their notoriety as problematic tenants.

A Breeding Pair on the Loose

This eagle pair already had a reputation in the neighborhood. They had previously nested in a cellular antenna attached to a nearby transmission tower before the communication company permitted and executed a nest eviction at the end of the breeding season. In October 2020, the pair was tracked to a nearby transmission tower and Pepco was alerted to a tentative nesting attempt. All signs indicated these eagles were undaunted by the loss of their nest, determined to retain their breeding territory, and partial to engineered structures.

The situation was increasingly familiar to Pepco's avian program manager, Cristina Frank. Once federally listed as endangered due to environmental contamination by the insecticide DDT, the bald eagle is an Endangered Species Act (ESA) success story. From just 60 breeding pairs in the 1970s, the Chesapeake population of bald eagles rebounded strongly thanks to a ban on DDT, robust regulatory protections, and focused restoration efforts. The Chesapeake population grew from nearly 650 breeding pairs in 2001 to 3,000 pairs in 2020, an annual increase of 8% to 10%.

Eagle Egg Microclimate

In March 2021, Pepco had an urgent need to prevent another power interruption by trimming high risk sticks from the 908E nest, but eagle nest management or disturbance requires a federal permit. A sticking point for the U.S. Fish and Wildlife Service was the presence of an egg: regulators were concerned that if the adults left the nest for an extended period, the exposed egg would cool beyond the point of viability. Weather conditions in early spring are unlikely to be ideal, but a nest trimming outage requires advance planning.

Cristina Frank, Pepco's avian program manager, secured the necessary permit with an innovative proposal to maintain a viable egg temperature and protect the egg from physical disturbance during nest trimming. Conceived and developed specifically for this project by EDM International, Inc., the prototype Eagle Egg Microclimate (EEM) consisted of an insulated 18-inch protective dome, a thermostat-controlled heating pad, and a power bank. An ancillary remote thermometer allowed observers to monitor the interior temperature of the EEM from the ground.

On the morning of the nest trimming the air temperature was 52°F, too low for an eagle egg to withstand for long. The female eagle remained in her incubation posture until the linemen were nearly eye-to-eye, then flew off, allowing them to carefully place the EEM over the egg. The EEM quickly increased the temperature near the egg by more than 20°F, affording the crew ample time to safely complete the nest trimming. When the crew returned to the ground, the female immediately returned and resumed incubation. The egg hatched in April and the young bald eagle made its first flight in June. Shared successes like the EEM build a foundation of trust between operators and regulators, enabling them to respond more effectively and cooperatively to wildlife challenges.

A power station is visible from the eagle nest. Photo courtesy of AUI.

The platform was made of aluminum and vented from below. Photo courtesy of David R. Smith, Coastal Resources, Inc.

"It's hard to believe they were critically endangered just decades ago," notes Frank, "I'm proud that our industry has contributed to the recovery by reducing utility-related electrocutions."

The bald eagle was delisted under the ESA in 2007, though stringent Bald and Golden Eagle Protection Act safeguards remain in place. Today, bald eagles are a common sight in the coastal Mid-Atlantic states, where habitat is exceptional and foraging opportunities abound. In fact, eagles have become so common that they vigorously compete with one another for breeding territories and prime nest sites — trees and snags with sparse branches, commanding views, and access to open water with abundant fish.

Over the last decade, many breeding pairs have discovered that a transmission tower is a fine substitute for a tree. Transmission operators may dispute such a determination: High-voltage clearances are large enough to protect eagles from electrocution, but sometimes too small to protect the system from eagles. Studies by Pepco and its sister utilities in the region have shown that nest-related outages caused by eagles and other large birds are a legitimate operational concern, and Pepco is acutely aware that such outages also pose a risk of wildfire ignition.

Nest Response Planning

Eagle nests are protected year-round. Unlike most species, a federal permit is required to remove an eagle nest, even outside the breeding season. In the case of the 908E tower, emergency monitoring revealed an additional sensitivity: The pair had already laid an egg, meaning the nest was demonstrably "in-use." In response to an early briefing, the U.S. Fish and Wildlife Service (USFWS) cautioned: "Securing a permit for removal of an in-use nest is a process, and not to be taken lightly." As a result, Frank and the Pepco team resigned

themselves to a minimally intrusive stopgap measure. According to the terms of the USFWS Eagle Nest Take permit Pepco received, they could only trim the nest sticks posing the greatest outage risk, and they could do so just once during the breeding season.

Nest trimming would be a temporary solution, at best. Pepco had previously seen coastal storms blow entire eagle nests from lattice towers, and unused nests slowly shed sticks as they decayed. In either case, the volume of material posed a threat to the operations and integrity of the transmission grid. Eagle nests start big and can grow to a ton or more as sticks are added each year. Collapsing nests can bridge even large phase-to-ground gaps. Falling material is not the only nest-related threat to reliability. Eagles' feces also can cause outages if the insulators become contaminated and degraded, or if a long (60-in. plus) feces "streamer" compromises the conductor's air gap. In this case, Pepco investigators were confident the fault was caused by sticks.

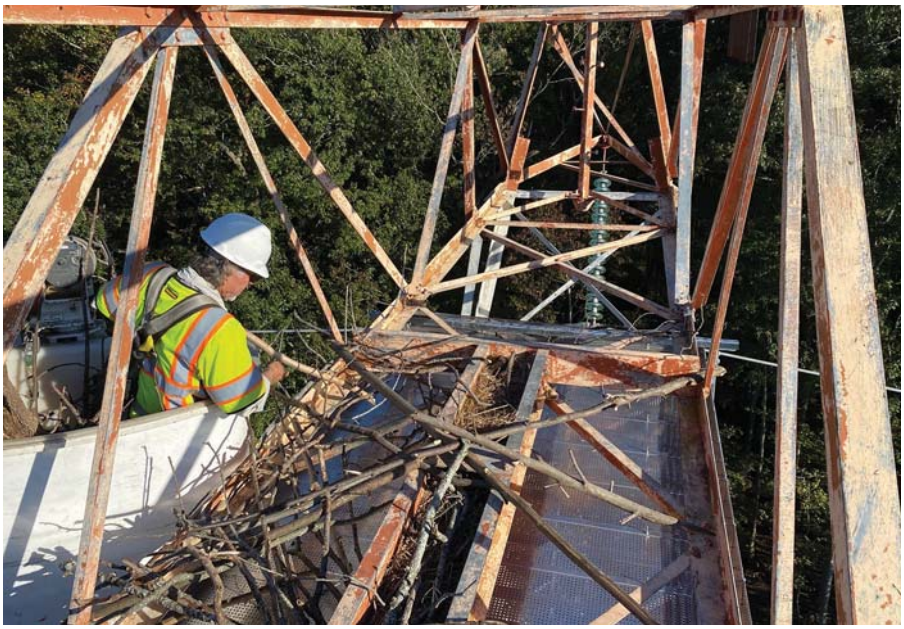
Frank led the long-term planning effort for the 908E nest, working with wildlife-power line interaction specialists EDM International, Inc. (EDM) to refine three management alternatives. The first was scheduling an annual nest trimming outside the breeding season to reduce both the number of sticks that would break loose and the likelihood of a related outage. The second was relocating the nest to an engineered platform mounted lower on the tower or at the edge of the right-of-way. The third option, "nest containment," was more innovative: installing a tray beneath the existing nest to collect unstable material and to prevent sticks from falling into the conductor zone.

Permitting Process

In preparation for this pilot project, Pepco secured a U.S. Fish and Wildlife Service (USFWS) Eagle Nest Take permit, which authorized emergency nest trimming during the breeding season, followed by containment tray installation outside the breeding season. This was a "specific permit" authorizing explicit activities and requiring a unique suite of mitigation actions, both tailored to the situation at hand.

In September 2022, USFWS proposed modifications to the Bald and Golden Eagle Protection Act that would create a "general permit" scheme for Eagle Nest Take and Disturbance Take. With a goal of reducing the eagle permitting burden for the Service and applicants, a general permit with generic "best practices" mitigation requirements would be issued automatically upon the completion of an online form and payment of a reasonable fee. At the time of this writing, it is uncertain whether the general permit system will be finalized, and if so, the specific application and reporting procedures.

With these uncertainties in mind, it will be essential for any utility considering eagle nest containment to discuss the permitting process directly with their regional USFWS Migratory Birds Permit Office. Utilities also are invited to contact the authors of this article for additional eagle nest containment information.



To encourage re-use of the site, PHI placed sticks from the previous nest (which had fallen off the tower after the 2021 breeding season) on the bridge above the tray. Photo courtesy of David R. Smith, Coastal Resources, Inc.

What to Do?

The decision-making process was closely informed by two prior experiences managing eagle nests on lattice towers. Relocation and removal both required lengthy permitting efforts, mandatory mitigation, armoring towers with large bird spikes, and ongoing monitoring. Additional labor was needed to track and haze nest attempts on unprotected structures. These operations were resource-intensive: one-year costs ranged from $220,000 to nearly $400,000. Another drawback was the recognition that relocating a nest does not guarantee its use, since eagles could instead select any unprotected tower nearby. Annual nest trimming was unappealing because it would require a new permit each year, and because success would be uncertain. After all, a storm could blow even a trimmed nest into the conductors.

The level of effort for nest relocation, removal, or ongoing scheduled trimming was unsustainable, much less scalable to meet exponential eagle population growth. As a result, these alternatives were rejected. Pepco operations managers saw clear benefit to evolving from a "zero tolerance for nests" policy toward a "zero tolerance for nest outages" approach.

Nest containment was the alternative deemed most likely to prevent future outages. A tray mounted below the nest would prevent stick-related service interruptions, and allow the eagles to retain their preferred site would preempt a fruitless chase from tower to tower in subsequent breeding seasons. Direct costs would

be far lower than the alternatives if the containment tray could be affordably fabricated and efficiently installed. Unlike the alternatives, containment had the potential to be a scalable eagle nest management alternative.

Although a permit would be initially necessary, if eagles were not negatively impacted, and containment could be implemented outside the breeding season with no disturbance to nesting materials, a federal permit might eventually become unnecessary. In the absence of a permit, there would be no mitigation or monitoring requirements, further streamlining the process. The potential upside of nest containment was extraordinary, and Pepco stakeholders were excited to carry out a proof of concept.

High-voltage clearances are large enough to protect eagles from electrocution, but sometimes too small to protect the system from eagles. Photo courtesy of Rick Giammaria, Pepco Holdings, Inc.

Nest Containment

Containment was an intriguing concept, but not a proven practice. The first containment pilot project in 2017 ended in failure when a mesh panel tore loose in a storm and had to be removed. This time around, Pepco needed a bomb-proof tray that could be installed from below the bridge without disturbing the nest and accommodate uncertainty in the tower's dimensions.

Frank and EDM had previously worked with independent line contractor AUI Power (AUI) to develop avian mitigation for a thorny switch problem. AUI had impressed Pepco with their ability to understand the problem and quickly develop and fabricate a solution their own personnel could install under difficult conditions. Why not rely on field experts to design and implement a nest containment solution that would be

Eagle nests can pose a threat to transmission equipment as they decay, are knocked down by weather, or eagles themselves can drop debris or waste onto lines, causing faults. Photo courtesy of Rick Giammaria, Pepco Holdings, Inc.

practical to install and stout enough to meet Pepco's loading requirements?

AUI's design effort was led by Dusten Moir, who had risen from journeyman lineman to overhead operations manager. The AUI Fabrication team worked long hours to develop a prototype solution that would be suspended from the tower bridge to avoid disturbing existing nest materials. The frame would support a series of sturdy fabricated panels that were vented to allow drainage and reduce wind loading. Custom anchors allowed total flexibility in tower attachment, ensuring that the tray load would be borne by the strongest areas of the bridge. True to their field-savvy roots, AUI performed a dry run on the installation before the design was deemed satisfactory.

"This is going to be a complex install with a lot at stake," explained Moir, "but because the linemen and the Fab Team worked out the kinks on the training yard tower, we are confident we will stick the landing."

Pepco's confidence in AUI was rewarded in the fall of 2021. Although most of the 908E nest had fallen through the bridge by July, eagles had placed several new sticks by September, and Pepco proceeded with the planned October outage. Resident eagles supervised the beginning of the six-hour installation from a nearby tower. Once the containment tray was secured, David Smith, a wildlife biologist from Coastal Resources, Inc., tutored the AUI linemen in building a rudimentary starter nest on the bridge from scavenged sticks.

"The scientific literature describes this as 'augmenting the odds of anthropogenic nest site adoption,' but it's more fun to imagine rolling out the red carpet for honored guests," Smith said.

The 908E installation went smoothly, but a nearby osprey nest provided a better test, weeks later. Instead of removing it outside the breeding season, Frank decided to retain and contain the osprey nest, offering the eagles a ready-to-use alternative to the 908E site. Though the osprey nest was bulky and dense, the AUI crew was able to install the containment tray in less than three hours, with minimal disturbance. Security chains were added to the tray as a redundant safety measure to protect the insulators and conductors in a worst-case scenario. AUI's design was proven to be practical to install and robust, but success hinged on the next question: How would the eagles respond?

Despite the loss of the previous year's nest and the presence of a new containment tray, the eagle pair was undeterred. Perhaps buoyed by their previous success at the 908E site, the pair added sticks to the man-made proto nest in December and January. By the end of February, the pair was incubating eggs. Observers documented a chick in March, and later determined the nest contained two healthy eaglets, which successfully fledged in June. The other containment site was not monitored, but observers opportunistically ogled osprey copulating on the tower. In short, both pairs of birds responded well to nest containment.

Conclusions

This pilot project demonstrated that nest containment, carefully implemented by an expert team with diverse and complementary

skill sets, can be mutually beneficial for all parties. For the eagles, containment provides additional security, allowing them to retain a favored nest site and reducing the likelihood that a successful nest will be lost to a storm. For transmission operators, containment protects reliability and reduces safety risks, at a cost estimated to be 90% lower than nest removal. For regulators, containment reduces conflict between humans and protected wildlife while offering distinct advantages to each. Containment is a win-win-win.

The fledging of two juvenile eagles from a contained nest represents a conservation success and a system-hardening triumph. From a reliability perspective, a mitigated eagle nest in a known location is far preferable to an unsettled pair that might build a hazardous nest on any unprotected lattice tower. Pepco is committed to providing safe, reliable and affordable power, being a good environmental steward and fulfilling the company's regulatory obligations. Innovation, creativity, and adaptability have allowed Pepco to fulfill these commitments in the past, and will remain vital to serving homes and businesses in some of the finest bald eagle habitat anywhere. Once a rarity, eagle nests on transmission towers have become commonplace. To the benefit of the eagles and operators, customers and regulators, Pepco believes that nest containment will one day be seen as an important chapter in the bald eagle recovery story. TDW

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LIBBY MOJICA (*lmojica@edmlink.com*) is a certified wildlife biologist at EDM International, Inc. in Fort Collins, Colorado. She finds solutions to bird management challenges in the electric industry using science to guide management recommendations to minimize nesting, electrocution, and collision conflicts. She has a B.S. from Trinity University and a M.S. from The University of Georgia.

For More Information

EDM International | *http://edmlink.com*

No Easy Answers:
Transformer Supply Crisis Deepens

JEA said it was temporarily using overhead transformers in undergrounding applications instead of pad-mounted units. Photo by JEA.

Transformers of all types are now harder for utilities to source, leading them to purchase overseas for higher prices, longer wait times and the growing concern that a needed part might not arrive when it is badly needed.

By **JEFF POSTELWAIT**, Senior Editor

When I wrote last summer about how supply chain issues had made electrical transformers difficult to come by, I suspected I would be revisiting the topic soon, as this was a wide-ranging problem with no easy answers available. That was confirmed when a colleague sent a notice from a small municipal utility in the middle of the U.S. alerting everyone involved that it could no longer accommodate any projects that required a new distribution transformer because there were simply none that could be gotten.

"We do not have any timeframe of when to expect deliveries of transformers as suppliers are unable to provide a date of when to expect deliveries to restart," according to the announcement. "We apologize for the inconvenience and ask for your patience as this issue is affecting electric utilities nationwide."

Reaching out to utilities of different sizes, locations and ownership models, it became clear that the issue was deepening — with wait times growing longer, and shortages occurring with all kinds of transformers, not only the large, pad-mounted variety.

A common refrain from respondents was: We still have some transformers in stock, but an unexpected event could change that, and if it did, it is unclear how we would work around the shortage.

Waiting is the Hardest Part

At Otter Tail Power Co., an investor-owned utility providing service to about 133,000 customers in Minnesota and the Dakotas, utility staff are seeing lead times grow by leaps that would have previously been unthinkable.

"We are delaying some of our underground projects due to the lack of padmount distribution transformers on-hand. Lead times are extending to lengths never seen before, we are being quoted a lead time of 202 weeks on padmount transformers. That's 3.88 years," said Gregory Rausch, sourcing manager for Otter Tail.

Previous lead times ran about 16 to 20 weeks, Rausch said. The situation began to worsen in spring 2020 with COVID-19 shutdowns in full force, and manufacturing has since been unable to dig out of the hole — with demand running as high as 500% more than previous years.

It should be noted that the lead time figures provided by Otter Tail were a bit of an outlier, with some utilities that responded to this story seeing shorter wait times and merely concerned about the possibility of longer ones. However, Otter Tail was not unique in wait times lasting multiple years.

Should these trends continue, Rausch said commercial and industrial customers could be impacted, and some new residential customers are already being told they may have to wait longer than normal to be connected to the power grid.

"We are running out of options, if we can't get more transformers and we use up our remaining inventory, we'll need help from somewhere," Rausch said. "In the meantime, our resourcefulness is keeping us alive, we're using refurbished transformers when we can get them. We're using whatever we can get our hands on. But the bottom line is, utilities are using more than what's being manufactured, and that cannot continue very much longer."

After hurricane season began in the fall, he said, orders were pushed back two to four weeks due to transformer makers needing to respond to the demand for transformers in storm-hit areas. "We can no longer trust manufacturers order ship dates; we don't plan any projects around the manufacturing ship date because it's just too unreliable," he said.

Transformers stored outdoors on wooden palettes at a City Utilities of Springfield facility in Missouri. Christopher Jones, Vice President and Chief Electric Operations Officer said his utility has had vendors not renew multi-year purchasing agreements, which has forced them to re-bid contracts. The utility still has a minimum level of inventory to respond to storms, he said. Photo by City Utilities of Springfield (Missouri)

Distribution equipment frames a distant wind farm. Development of renewable energy projects is one drivers of demand for new transformers. Photo by David Gaylor, Dreamstime.

Manufacturers are doing the best they can to communicate when stock will be available, he said, but added that the stress on the supply chain is such that there is no remaining transformer reserve for many utilities to rely on, so that a sudden event like a hurricane can result in even longer delivery times.

"It's a very serious issue. The chief procurement officers in the Edison Electric Institute companies have been meeting bi-weekly since this spring about the seriousness of this issue," he said.

According to the EEI, 75% of investor-owned utilities reported having lower reserves of pad-mounted or pole-mounted distribution transformers last year than in 2018. EEI also found it can take two years or longer to source new transformers.

The Electricity Subsector Coordinating Council (ESCC) found last year that 90% of investor-owned electric companies reported a "high" or "medium" risk of running out completely of at least one distribution transformer voltage class. About 60% of IOUs have had to cancel or put off planned projects due to the shortage, according to ESCC.

Entities representing the industry have called for several remedies, including making funding available to through the Defense Production Act to boost domestic manufacturing, lowering barriers to entry for critical manufacturing jobs, and loosening efficiency restrictions on using different types of transformers in different configurations along the grid.

The American Public Power Association vented its frustration just before the new year when the omnibus appropriations bill, despite calls from the APPA and other trade groups, did

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Electrical steel ribbons in a factory. Manufacturing of amorphous steel and other specially made metals is hitting capacity in North America, which is a primary driver for transformer scarcity. Photo by Bambulla, Dreamstime.

not earmark any DPA funding to help ramp up transformer production.

"This is a critical issue that several industries have raised, and on which the President has called for action. Despite our collective pleas over the past year to address this issue, supplies continue to dwindle, demand far outpaces production, and if action is not taken in the near term, the U.S. will face electric reliability concerns," said Joy Ditto, president and CEO of APPA.

The National Rural Electric Cooperatives Association and the APPA also asked the Department of Energy to temporarily suspend efficiency rules on transformer manufacturers. This change would lower demand for the specially milled steel that manufacturers say is one of the primary drivers of the current product shortage.

Manufacturer's Take

Back in 2022, Bill Miller, senior vice president of Marketing and Sales for Hitachi Energy's North American transformer business, said the situation had not improved since 2020.

Electrical steel is placed onto racks at a factory. Trade groups have called for the U.S. federal government to use the Defense Production Act to ramp up domestic production of this key material for making transformers. Photo by Nordroden, Dreamstime.

Bo Mackey, T&D apparatus supervisor, and Crystal Williams, distribution engineering supervisor for Eugene Water & Power. EWEB was seeing transformer delivery times grow to up to 38 months. Photo by EWEB.

When asked again, Miller now says the situation for manufacturers is changing, with some supply chain issues improving, but he added that the continued scarcity of specially milled amorphous electrical steel in North America is one of the primary drivers for the scarcity of transformers.

It takes a lot of specially manufactured materials to make transformers, including specifically engineered components, grain-oriented electrical steel (GOES) for cores, high-cellulose papers, transformer oils, aluminum and copper wire. Most of these are subject to raw material price volatility or supply disruptions in the global market.

Amorphous steel and GOES are made by rapidly cooling a molten alloy so that crystals do not form. This makes a thinner electrical steel that enables lower core losses in a transformer thanks to different magnetic properties in the core, according to Jeremy Dunklin of the American Council for an Energy-Efficient Economy's Appliance Standards Awareness Project.

Dunklin said the annual domestic capacity of amorphous steel would need to be nearly doubled from 45,000 metric tons to 75,000 metric tons over the next two years to meet the majority of the domestic demand for distribution transformer cores.

"Grain-oriented electrical steel continues to be pretty stressed globally," Miller said, with only one supplier left on the continent. "The demand for the material is still very high. We don't see that the supply has growing in step with demand. So, if there was any scarcity on supplies for transformers, it would be in the GOES category."

Hitachi is the world's largest consumer of GOES, Miller said, adding that much of the world's supply came from Russia, which Hitachi has not done any business with since shortly after the country's invasion of Ukraine.

Meanwhile, China, another of the most important specialty steel makers, is electing not to make as much GOES for export, instead using its own supply domestically.

"China's zero covid policy was a factor. Over the last six to 12 months, it's been increasingly difficult to keep the supplies we get from Asia flowing," Miller said.

Market volatility for transformer oils and copper wire have fallen, providing some relief. Another pressure is now coming from the ongoing chip shortage. The shortage of semiconductor products was a huge pressure on many industries throughout 2022, but now shows some signs of slackening as economic growth plateaus slightly. Miller added that transformers usually do not need semiconductor components unless a customer specially requests them.

Joseph Nasworthy, a utility worker at JEA in Jacksonville, Florida, sorts items in a warehouse. Like many utilities, JEA has also had to look overseas to find the equipment it needs. Photo by JEA.

Riding the Storm Out

While some utilities are seeing their equipment orders move further down the queue due to severe weather impacts, the situation is also difficult when you are in the path of the storm.

Jay Stowe, CEO and managing director of JEA, the municipal utility for Jacksonville, Florida, said his utility is subject to the same long lead times and must plan ahead.

"JEA planned ahead in 2021 to ensure we had transformers for our 2022 storm stock, and we have already placed orders for FY23 storm stock. We also have been able to establish safety stock to make sure we have units on hand for repair and maintenance work. Units received above and beyond those two preventative supply efforts will go to new development projects," Stowe said.

ONE UTILITY'S STRATEGY

I also talked to my local utility here in Oregon, the Eugene Water & Electric Board, which said it had developed a plan to stay ahead of the issue of supply shortages. EWEB is Oregon's largest customer-owned utility and provides water and electricity to about 200,000 people — including me — in the Eugene area.

They wanted me to tell you that elements of this piece were originally published in the October 2022 bulletin of the Northwest Public Power Association and written by EWEB communications specialist.

Silence from suppliers, slippage on orders and increasingly competitive contract bidding — these were the early signs of a supply chain disruption on the horizon.

In the fall of 2021, after a year and a half of leaping hurdle after pandemic-driven hurdle, officials at EWEB realized that supply chain shortages meant the race wasn't over.

"Our ears perked up and our team jumped into crisis control mode," said Tyler Nice, EWEB's electric operations manager.

Like utilities across the nation, EWEB is no stranger to equipment shortages. Below are some stories of how EWEB navigated a tighter market for padmounted transformers, cable and smart meter chips.

Tyler Nice, EWEB Electric Operations Manager

In the fall of 2021, we noticed an information shift from reliable suppliers. Delivery estimates were changing. We were accustomed to delivery windows of nine to 12 weeks on transformers from the day we placed the order, and then we were being told it could take up to 38 months.

We collected equipment replacement data from the last three large storms, taking note of what materials we used and the amount we had on hand at the time of the storm. One incident we examined was a large ice storm that, because of its unusual nature, provided good information about what we could expect during an uncommon event. We looked at average yearly totals of equipment failures and replacements. We considered the prior two years of customer-driven projects.

With this data in hand, we could justify placing very large and immediate orders.

Once we had an idea on the quantity of material and equipment we needed, the next step was getting creative with competing contracts. We're in a seller's market, which means bids are rising and suppliers have the upper hand in negotiations. Our regular suppliers couldn't fulfill the large orders we were seeking, so we found new suppliers outside of our normal territory.

We asked ourselves: What are we willing to sacrifice to get the quantity of equipment we need? Quality of transformers has always been very important to us and in the past, we've been very selective. But in this market, we had to be more flexible while maintaining contract protection to ensure high value for our customers. We sacrificed some specific technical requirements and settled on some meeting the baseline. But we still ran into some dead ends and turned away a few suppliers for lack of experience in the utility market.

We prepared as much as we could, we got very important orders placed, and now it's a waiting game. We're still having regular meetings to strategize our next move and we're trying to be one step ahead as much as possible. Fortunately, we haven't materially delayed any customer projects because of lack of equipment, but we have had to phase back some projects.

My advice to another utility would be to listen to the folks on the front lines. Stay open to ideas from your employees in all departments – field crews, design, engineering, purchasing and customer reps. Maintain a space that welcomes unique concepts because it really is a new world and it's time to start thinking outside the box as we navigate forward.

Bo Mackey, EWEB T&D Apparatus Supervisor

In 2019, we started work on a 10-year capital improvement plan. At that time, we didn't know a pandemic was around the corner and we didn't know we'd be facing a very tough supply chain shortage in the coming years. Timing, planning, and a little bit of luck all played a role in putting us in a favorable position for what was ahead.

From 2019 to 2021, our electric capital budget increased significantly by 13% to provide funding for projects such as modernizing information technology, upgrading meters, and replacing aging infrastructure.

Our budget enhancements couldn't have come at a better time because by fall 2021 we started to hear about extended delivery timelines. We had a robust budget in place when we needed it most and, thanks to our 10-year capital plan, we had already put in the

JEA has also had to look overseas to find the equipment it needs. Among the hard-to-find items are padmount transformers, cabling, pole-mounted transformers and associated hardware.

"We have found various creative solutions to these challenges, including turning to overseas manufacturers for transformers and other supplies, an option that is more costly. Transformer lead times for padmounted units have grown from three to four months prior to the pandemic, to 17 months since supply chain disruptions started in early 2021," Stowe said.

Besides sourcing items overseas, Stowe said JEA is taking some concrete steps to address the shortages, including ordering more materials to compensate for long lead times, temporarily using overhead transformers in undergrounding applications instead of padmounted units, refurbishing transformers in house and "harvesting," which means redeploying underused transformers. Stowe is also co-chairing an ESCC supply chain "tiger team" of CEOs that is pushing for collaboration across the industry as well as the federal government.

Doubt on Federal Action

While trade groups like the APPA, EEI, ESCC, NRECA and others strive to bring attention to this issue, those on the forefront of the issue are worrying whether the shortage is being looked at with the urgency it deserves.

work on strategizing for the big projects over the next decade. We knew we had to start ordering now and not later because delivery estimates jumped from weeks all the way to years in some cases.

Our perspective shifted for how we placed orders. For instance, now we're placing large orders before we really have the specifics on design and engineering. But we know the plan is set, and that justifies the quantity that we order. This year we were able to secure a five-year contract for 13 large power transformers to support substation rebuilds. We have the confidence to place significant orders like that because even if we don't use those transformers, it's still useful for us to have the spare equipment and we're not losing money. In fact, we've already planned for it.

My advice to others is to remember that it's not business as usual. Maintaining transparency and frequent communication about wait times for equipment with your large customers is important. Like us, they are accustomed to a certain way of doing business and a certain expectation of time frames on projects or repairs. We need to be proactive and keep them informed when those time frames shift.

Crystal Williams, EWEB Distribution Engineering Supervisor

I came into this position in December of 2021, and it's been full throttle ever since. Our distribution engineering team has really taken the lead on contacting suppliers, doing reference checks, making sure we can meet specifications and then presenting our findings to the purchasing department.

Our goal has been to stay ahead of the issue, and we've been able to do that by being creative with our designs and how we use alternative materials. We've been able to work closely with the line crews to develop out-of-the-box ways to keep customers connected or to design new connections.

Eugene is expanding rapidly, and it's been a challenge to make sure we can fulfill those projects on our end. For instance, there are big housing complexes under construction right now and they need large transformers that we just don't have in supply. Luckily, we have those orders scheduled to arrive this fall and our design techs have been able to partner with customers to phase projects and plan around any impending impacts.

The key has been to keep our customers informed and letting them know we might not be able to start on their project immediately. We've made changes to our terms and agreements, including a clause about how project schedules and costs may be susceptible to change because the market is fluctuating. So far, our customers understand the issues and they've been receptive to change.

My advice for others would be to find alternatives, whether that's with your equipment suppliers or your designs. Make sure to do your reference checks because not every supplier is the same. When you're scoping out a new supplier, you'll want to be as organized as possible beforehand. Do your research on what you're looking for and be ready for flexibility in your terms and conditions, because if someone out there has the materials you need, then they're in the driver's seat. It's going to be important that you're ready to buy even if it's not on the terms you were hoping for.

Frank Lawson, EWEB General Manager

For EWEB, organizational resiliency is the north star of our 10-year Strategic Plan, and not just from the standpoint of operational continuity. Every decision can be evaluated through a resiliency lens, from creating budgets and capital plans with financial headroom, to attracting and retaining diverse and adaptive talent.

But it's one thing to put words about resiliency into a strategic plan, and it's another thing to bake resiliency into each business function and to use that plan as a tool to help evaluate tradeoffs between short-term efficiency and long-term value.

I must commend our staff and board of commissioners for operationalizing resilience in a way that allowed us to respond effectively to supply chain shortages. Our board approved a capital plan and budget with the right amount of absorptive capacity, and consistently engages in proactive and future-oriented decision-making. And before supply chain shortages became an industry-wide crisis, our teams pulled together quickly to find opportunities and come up with innovative solutions.

Providing power and water is a 24/7/365 job with no end date, and we must be prepared to deliver those critical services through both stable and unstable periods alike. Resilience in all functions is key to operating in a turbulent environment, whether it be a changing climate, new technology, developing markets, political and regulatory flux, natural and human threats, or evolving diverse community expectations. TDW

In Roseville, California, a suburb of the state's capital, Sacramento, the city-owned Roseville Electric Utility might be having an even tougher time if not for an economic slowdown, inflation, climbing interest rates and the utility's own careful planning, said Dan Beans, electric utility director.

"We have sufficient reserves to cover the loss of transformers for an estimated two years. We have a small amount in addition to our necessary maintenance reserves to support new construction, but these are limited and depend on the size of the transformer," Beans said. "With our planning, we have procured what we need for the projects that we know about today, but the next project could be a different story."

Last year, delivery times for equipment climbed from three to six months to more than a year, and worse still, manufacturers offered no guarantee on delivery dates even as transformer prices climbed 40%, Beans said.

"Initially, delivery times for smaller single-phase pad-mounted units were the most impacted, with three-phase units continuing to go to production in a reasonable time. However, by 2022 Q3, 3-phase units appear to be similarly affected," he said, adding that the supply problem is spreading to affect other power grid components such as wire and meters.

Are federal leaders taking this seriously?

JEA is taking creative steps to address shortage, including refurbishing transformers in house. Photo by JEA.

"I personally visited six congressional offices and none of them were aware of the issue back in June," he said.

Using the Defense Production Act to boost manufacturing is a good idea, he said, but Congress has so far failed to commit any funding to support the idea even after a year of advocacy from utilities, home builders and other stakeholders.

"Without funding, the DPA is just another acronym and does nothing to help the situation," he said. "It appears that until customers are not able to have power restored, only then will the government act. Sadly, this will come at a high social, economic, and environmental cost."

Furthermore, instead of relaxing distribution transformer efficiency standards as the APPA, the NRECA and other groups asked, the DOE issued a noticed of proposed rulemaking Dec. 28 to increase the efficiency of transformers by using even more of the already scarce electrical steel — something Beans said will create a lot of issues.

Dunklin from ACEEE said GOES and amorphous steel each have only a single domestic supplier: Cleveland-Cliffs for GOES and Metglas for amorphous steel. DOE's proposed rule states that Cleveland-Cliffs does not have the capacity to manufacture high-grade GOES to serve the entire U.S. transformer market, meaning the U.S. is dependent on foreign steel mills. Further, the domestic GOES market is under pressure from the electric vehicle market as lower grade non-GOES electrical steel is used in EV motors.

Because GOES production can be shifted to non-GOES products at modest cost, many manufacturers have converted GOES production lines to non-GOES to serve the rapidly growing, and more lucrative EV market, meaning that the burgeoning EV market may be in a raw materials competition with the power grid that EVs need to function.

DOE's proposed standards would essentially require that new distribution transformers use amorphous metal cores starting in 2027, Dunklin said. Absent standards, purchasers would need to start making more purchasing decisions based on total ownership cost and efficiency rather than upfront cost. Dunklin also notes that large transformers are not regulated by the DOE and would not be affected by this rule.

This concept may be a difficult sell for utilities, who are forced to weigh theoretical total ownership cost of equipment against a power grid that can't be repaired due to transformers being scarce.

"As a department, they appear not to understand or believe the seriousness of this issue. One group from DOE is trying to work with industry to find solutions while others are doing the exact opposite," Beans said. "It looks like things are going to have to get really bad before the feds will take meaningful action."

A Storm Strikes

Shortly before the new year, Peter Rossi, COO of Vermont Electric Cooperative was facing down a severe winter storm that would blow through the East Coast and New England that dumped lots of heavy, wet snow on the coop's service territory.

"The storm was very powerful, about two times stronger than a very similar South/Southeasterly wind event from 2017," Rossi said. "And it was emotionally draining working long hours through the entire holiday weekend."

The utility ended up having about 13,790 meters out out of about 41,000 at

the height of the storm, and had to address about 293 discrete outage events and deploy some 122 field crews — not including support staff. The utility is looking for a FEMA declaration now to recoup some of the $1.8 million spent on the storm restoration.

"We were able to stand our system back up in 5.5 days, which was a real testament to our preparation, management, and effort by all employees," Rossi said. "Lots of things went right, and as always, we are analyzing areas for improvement. But a success story is the investments we made in resiliency in certain areas of our system were not affected by outages on this storm. Storm hardening is real and can have a profound impact."

When asked whether global supply shortages were a factor in addressing the storm, Rossi said the simple answer is no because the utility kept a storm stock for this kind of event.

(Left) A winter storm swept through New England just before the New Year, causing $1.8 million in expense for Vermont Electric. The storm made some to worry that more storms might push utilities' storm stocks to the breaking point. (Right) Vermont Electric saw about 13,790 meters out of about 41,000 at the height of the storm, and had to address about 293 discrete outage events and deploy some 122 field crews. Photos by Vermont Electric.

"But we certainly depleted our stock of overhead transformers that are typical (e.g., 10 KVA and 15 KVA)," Rossi said. "If we have another event this winter, we could be in trouble."

Building a Way Out

In addition to the de-industrialization of North America that resulted in fewer steel mills, the transformer market itself has changed, Bill Miller with Hitachi said.

"North America is the most active market, depending on who you talk to, for transformers. What's happening in this market? About 90% of what we sold 10 years ago was to a utility company. Today, only about 60% goes to utilities and the rest will go to others, such as renewable energy developers or property developers who buy directly from the manufacturer," Miller said.

The customer makeup has changed in the past decade, with much of the growth happening in new areas: Data center hyperscalers, renewable energy projects and the oil, gas and chemical industries, each of which require transformers for their operations.

On the West Coast, the drive for undergrounding to protect the grid from foliage intrusion or sparking wildfires, also requires more transformers. The hurricane-prone East Coast states also have a growing need for transformers as storms intensify, he said.

Hitachi is expanding the manufacturing range and capacity of several of its plants, spending $10 million to modernize its Jefferson City, Missouri factory. More expansions will be announced in the future, Miller said.

T&D equipment manufacturers have to be concerned with how the power grid is holding up, he said, meaning the industry must act as a unit in the common interest of keeping the lights on.

"When [Lee County, Florida] was hit by [Hurricane Ian], we had to reconfigure some of our operations to serve that need. We do prioritize those kinds of disaster conditions to help the area recover from storms, and we don't charge any extra for that. We do it because it's the right thing to do," he said.

Larger utilities often have longstanding relationships with manufacturers, giving them allocated "slots" held for those companies based on their forecasts.

"Now that's a reliable way to book business. You have a repeat customer with a set rate of growth, you can project the growth of your business," he said.

Materials shortages caused a lot of jumps in pricing and in delivery scheduling, which makes everything less predictable.

"We used to quote a firm price and ship date. That was during times of more predictable inflation. With the volatility in commodity costs, shipping costs, we moved to variable pricing. For us, we use price adjustment calculation that is typically calculated three months prior to shipping, or about the time we purchase those commodities we need to manufacture it," he said.

It didn't used to be necessary to try to predict what a transformer was going to cost in three years, he said. However, now it's a full-time job trying to keep utility customers informed of these changes.

"That price adjustment method that we use increases transparency for the customer. We are seeing some commodities that are stabilizing in cost," he said. "So, they can see we aren't gouging. Some customers get credits if commodity costs fell."

Markets and geopolitics are difficult to predict reliably, but the industry can rely on two things: People will continue to need electricity and transformers will still be needed to deliver it.

"You can't trick the physics. We have had these transformers built a certain way for many years, and they were built that way for a reason. You need a certain amount of steel to step up electricity, and you can't trick the physics," he said. TDW

A sub-transmission line span in Helsinki. Helen is in the process of updating its power grid, including substation automation. Photo by Marko Hannula, Dreamstime.

Asset Automation Helps Finnish Utility's SAIDI

Helsinki's distribution network operator establishes the optimal pathway for asset automation to improve reliability and reduce maintenance costs.

By **MIKA LOUKKALAHTI**, Helen Electricity Network Ltd.

Helen Electricity Network Ltd. is the city-owned electricity distribution network operator for Helsinki, Finland, regulated by the Finnish Energy Authority. The utility's parent company, Helen Ltd., is responsible for the retail market, electricity and district heating businesses, and new customer energy services. Helsinki has a population of around 660,000, and the distribution network supplies more than 400,000 industrial, commercial and residential customers. As part of the business operation model in Finland and for Helen, all network construction and maintenance work is outsourced to service providers with long-term contracts. The large project contracts are awarded in compliance with the EU's open competition procedures.

As Helen is city-owned, the customers are, in fact, the owners of the utility. Therefore, providing a reliable and quality supply at a reasonable cost is an ever-present target and challenge. The city's largest customers include public and private services that are highly vulnerable in the event of an electricity supply failure, which has customer interruption costs of some €33/kWh (US$40/kWh) in the city center.

Helen has made many major investments in its 110-kV sub-transmission network, which is meshed connected with N-1 criteria and sufficiently robust to distribute power generated by the city's combined heat and power (CHP) plants. Almost all the utility's existing 25 primary substations — equipped with SF_6-insulated switchgear — are designed with 100% redundancy, for example, with two high-voltage/medium-voltage (110/20-kV) transformers and duplicate 20-kV bus bars. The design reliability criteria also specify that all medium-voltage (10-kV and 20-kV) substations have 100% reserve-capacity interconnections from neighboring high-voltage/medium-voltage (HV/MV) substations.

The MV network consists of underground cables — meshed with open points and operated radially — throughout the city. Typically, the 10-kV radial networks have a capacity rating of 5 MVA and the 20-kV radial networks 10 MVA, but the current overall loading in the city is relatively low. Considerable efforts have been made to provide effective and efficient maintenance procedures for operational staff to manage network fault events, with a focus on asset automation.

Substation Refurbishment

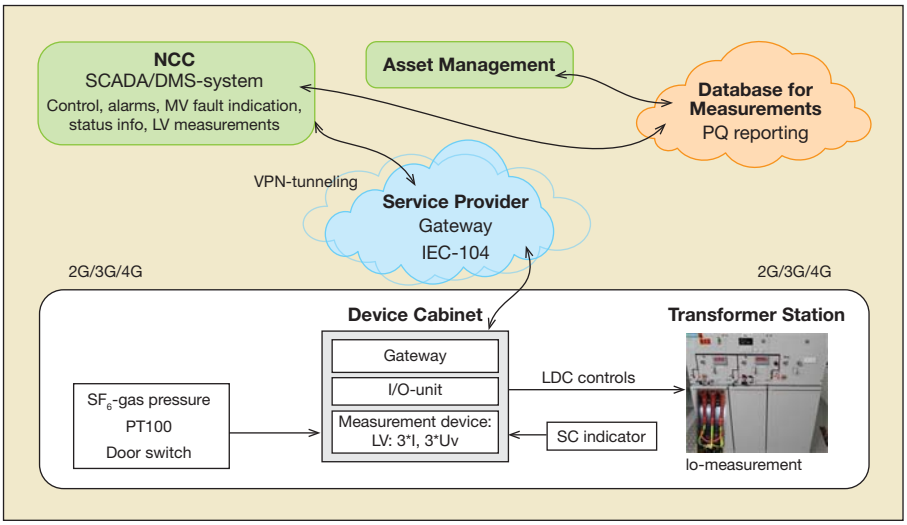
Helen commissioned numerous substations from 1980 to 1990 that have a design service life of 25 years to 30 years for the secondary substations and 40 years to 50 years for the primary substations. Helen conducted a refurbishment program of the secondary substations from 2007 to 2011, and in 2013, it decided to continue the refurbishments at an increased pace. The principal reasons for this decision were as follows:

- The secondary systems were aging, as their optimal lifetime was only 50% of primary substations.
- Fault rates were increasing on products no longer supported by the manufacturer (Siemens AG).

With self-supervision, it was possible to achieve higher reliability and halve the periodical protection testing costs by increasing the test interval from three years to six years.

Helen also decided to invest in new cost-effective, commercially available automation-driven devices with the following features to improve distribution network reliability:

- Coverable disturbance and event-recording functionalities
- Protection functionalities like MV cable terminal earth-fault function, directional-overcurrent function, MV short-circuit location
- Substation automation and bus technology (IEC 61850) enabling large volumes of signals from remote terminal units (RTUs) and supervisory control and data acquisition (SCADA) with more accurate real-time information on primary and device faults for operators, improved interoperability between devices from different manufacturers, and the use of fast generic object-oriented substation event (GOOSE) signals between intelligent electronic devices (IEDs).



Secondary substation automation

The completion of the first phase of the primary substation secondary system refurbishment projects continued based on turnkey contracts at the rate of two projects to three projects per year. The second phase, started in 2014, was completed mainly by Siemens using SIPROTEC 5 and SICAM products. The remaining substations were completed by ABB using REX 600 series and RTU560 devices. The pace of this refurbishment program has now decreased to a rate of one project to two projects annually. Today, all Helen's primary substations have a modern substation automation system, with the oldest substations still relying on serial communication.

Secondary Substation Automation

Helen's secondary substations were commissioned as a simple

The logo of Helen Oy, one of Finland's largest energy companies. Helen Electricity Network Ltd. is the city-owned electricity distribution network operator for Helsinki. Photo by Lev Karavanov, Dreamstime.

ring-main unit (RMU) type prior to the introduction of substation automation. Therefore, it was not until 2008 that Helen established the business case for automation. This was based on new technologies in the market, with the cost level of communication and technology decreasing while customer interruption costs in Finland were increasing. In 2009, Helen produced its full specification for secondary substation system automation:

- Commercial mobile communication (2.5G, 3G and 4G)
- Remote control of load disconnectors
- MV short-circuit and earth-fault indication
- Secondary substation alarm indication

A Finnish winter scene with a transmission pylon tower. The automation completed to date, has improved Helen's system interruption duration index (SAIDI) by reducing the interruption about 0.5 minutes per annum. Photo by Mikko Palonkorpi, Dreamstime.

- Distribution transformer load-level measurement
- Power quality measurement on low-voltage (LV) side.

The automated secondary substations selected were the normally open-point substations positioned at the 50% energy point on the ring-connected MV feeders. These automation projects were separate from the secondary substation refurbishment activity.

This automation program started after completion of the pilot project. By 2013, 300 pieces of automation equipment were installed as a turnkey project. As a result of competitive bidding in 2013, the project continued with another service provider. Between 2014 and 2019, another 350 secondary substations were automated. Furthermore, the telecommunication works were included in the agreement as well as turnkey maintenance of the complete system for 15 years. The project continues today as part of normal network construction with the automation provider and the network construction partner, with the intent that every new and refurbished secondary substation will be automated. This amounts to 50 automated secondary substations per year, including the telecommunication and maintenance activities included in the contract and in ongoing projects.

This increased level of automation already has resulted in significant advantages. For example, thousands of planned remote disconnector operations have been undertaken. On more than 200-MV network faults, automation has resulted in rapid restoration of supply to 50% of the affected customers and fault isolation has been accelerated for the remaining customers. Overall, the automation completed to date, has improved Helen's system interruption duration index (SAIDI) by reducing the interruption about 0.5 minutes per annum.

Asset management of secondary substations also has been optimized by using the available additional information from this level of automation. The measurement data has highlighted failure detections in the form of distribution transformer overloads and cooling failures, illegal entry of substations and incidents of high harmonic levels in the LV sinewave.

The measured mobile communication reliability level between SCADA and the secondary substations has been above 99%. Previously, the MV earth-fault indications had not been fully reliable because of Helen's compensated networks, but this is no longer a problem thanks to the utility's installed earth-fault protection.

Primary Substation Automation

Helen installed five new primary substations between 2009 and 2017 to satisfy the 1% to 2% growth in demand that has now ceased. As it had to maintain its 100% MV network reserve design standard, additional new MV substations were installed that have effectively decreased the geographical area supplied by the existing aging substations, thereby increasing network reliability.

All the new substations were delivered in accordance with the

turnkey contract, which included the installation of the process devices from ABB and Siemens. The substations were equipped with the specified latest automation technology:

- IEC 60870-5-104 remote control protocol with station level automation
- Some functional integration at HV level and one IED/bay at MV level
- Numerical IEDs with coverable self-supervision and fault recording.
- IEC 61850 station bus communication with rapid spanning tree protocol (RSTP)
- GOOSE signals mainly for control interlocking
- New advanced HV- and MV-level protection functions and other functions
- Transformer and switchgear condition monitoring (gas and partial discharge measurements)
- Sensors and IEC 61850-9-2 communication in one application (in the Kalasatama neighborhood).

The new substations have decreased the distribution area of the neighboring substations by 25%. This has decreased the SAIDI by around 0.5 minutes per year.

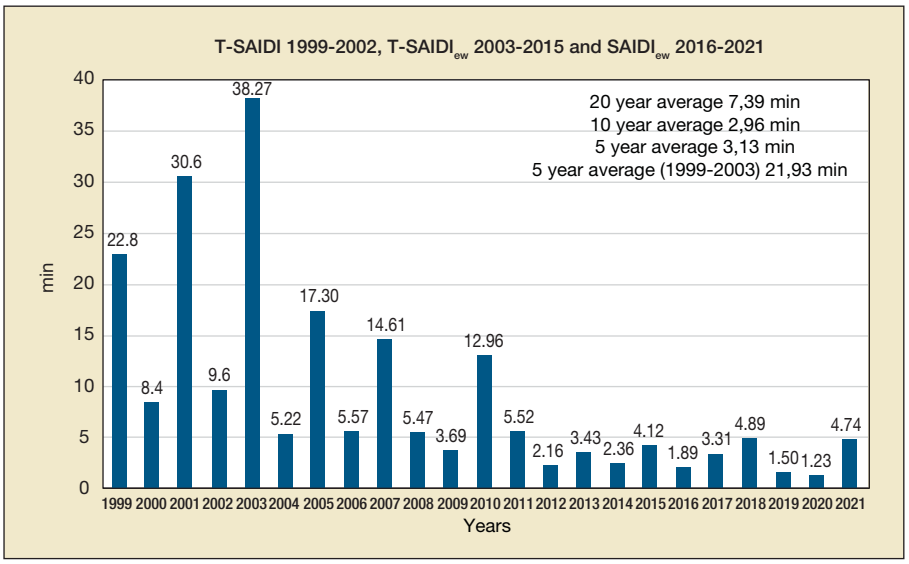
Earth-Fault Compensation

Some preconditions enable the MV network earth-fault protection to be used with an alarm-only method without tripping the circuit breaker. For this to be possible, earthing conditions must be solid and the touch voltages sufficiently low. Underground cable networks enable the possibility to avoid earth-fault arcs, as most of the fault current flows through the earthed cable screen. However, this requires the cable network to be in reasonable condition and not too old, to avoid cross-country faults.

In Helen's 10-kV isolated network, the earth-fault protection has been an alarm-only system for decades, operating with success. In the 20-kV compensated network, there was an earlier tripping system because of the higher earth-fault currents and touch voltages compared to the 10-kV network. In 2008, Helen kicked off a 20-kV earth-fault compensation project, aiming for the following results:

- Change the earth-fault protection of the 20-kV network to an alarm-only mode, so that 70% of earth faults can be isolated without outages to customers. In practice, this leads to a situation where only 50% of MV faults cause outages to customers.
- In compensated networks, the earth faults cause reduced stresses for the voltage transformers (Helen experienced many MV bus bar short-circuit faults between 1995-2007, caused by voltage transformer faults).
- Earth faults in a compensated network cause lower-voltage stresses (transients) transmitted to the LV side of the transformer.

The project started with a pilot installation at the 20-kV Pukinmäki greenfield substation. In 2012, the project continued with a full rollout and was finalized in 2018. The earth-fault compensation system is now installed in 13 substations, increasing Helen's total to 26 compensating systems.



Helen's reliability results, SAIDI-improvement.

Technically, Helen uses centralized compensation with 200-A to 500-Amp Petersen coils. The coils are connected to a 20-kV star point of the main transformers. Current injection is used to help the regulator see the size of the network without moving the position of the coil. The compensation degree is 10 A over-compensated and an additional resistor with 10-A current is used momentarily (for 3 sec) after the earth fault starts. Earth-fault protection is used with the cos φ function. Additional earth-fault indication devices, including intermittent, transient, harmonic and admittance functions, are used.

Commissioning tests must be conducted at night because primary earth-fault tests are executed with customers on the same network. At first, there were some problems and those tests also caused some cross-country fault situations. With the most recent projects, there have been no significant problems. All earth faults initially are intermittent earth faults, and they evolve usually within minutes to stationary-state earth faults.

The earth-fault protection and indication has been operating at a very reliable level. Helen has experienced many earth faults and 70% of them were isolated without outages to customers. The remaining 30% evolved into short-circuits or cross-country faults. No voltage transformer faults occurred between 2008-2020 and only one fault occurred in 2021. This likely initialized the high-phase voltage that arises during an earth fault. The effect of the compensation decreased SAIDI by 1.5 minutes annually.

Network Visibility

The last automated part of the network was completed at the customer terminals. In Finland, all utilities must provide customers with automated meter reading (AMR) systems. Helen installed digital energy meters and reading systems between 2008 and 2013, so its customers have had AMR for more than seven years. Customers get hourly billing according to real-time measurements and they can follow their demand using the customer service system. The reading is taken every day, with the communication mainly going to mobile devices.

There also is the possibility to have power quality information from these meters. Therefore, Helen's customer care center can connect to a single meter by the AMR system application and observe the measurements in real time. The AMR system also can provide power quality data in the form of the voltage level, voltage asymmetry, zero conductor broken alarms and so on. These alarms can be connected to Helen's distribution management system (DMS). The quality of this power quality data is not yet high enough to take it fully into account, but the zero-conductor broken alarm has proved to be highly reliable. Helen plans to integrate AMR data in an improved format to the current DMS system as well as to the next-generation DMS. The utility also is currently defining specifications for AMR 2.0 systems.

Significant SAIDI Reductions

Helen has sought to provide its customers with a high-quality, reliable and secure supply of electrical energy. As a result, its five-year average SAIDI level has decreased during the past 20 years from more than 20 minutes to 3 minutes. In 2020, Helen's SAIDI was only 1.23 minutes — a value that is probably among the lowest in Europe. Simultaneously, customer tariffs have been maintained at a reasonable level and, compared with the purchasing-power-adjusted residential customer tariffs of other European capital cities, Helsinki has the lowest tariffs.

These results are comparable with other cities that have underground cable distribution networks. They have been achieved by applying network design standards, a meshed network structure, strong and proven primary solutions, and effective maintenance and operation. Automation has played a significant role: Substation automation, secondary substation automation, earth-fault protection alarms and AMR systems have been the tools of choice for Helen coupled with appropriate and timely management investment decisions.

One important decision now facing Helen is the replacement of many fossil-fuel-fired CHP plants in Helsinki. The utility has decided to decommission the Hanasaari coal-fired power plant in 2023 and Salmisaari CHP power plant in 2024. The city will still require heat, so it is very likely large heat pumps will be needed to produce the energy currently available from the CHP plants and meet the increasing customer demand for electricity. TDW

MIKA LOUKKALAHTI (*mika.loukkalahti@helen.fi*) studied electrical engineering at Tampere University of Technology, receiving his master's degree in 1996. He joined Helsinki Energy in 1997 as a protection engineer, with responsibility for substation and network automation and power supply reliability. Currently, Loukkalahti leads life-cycle management and technological development at the utility. He is a member of the Finnish Study Committee and former member of the CIGRE B5 (Protection, Automation and Control Committee), and he has given several presentations at courses and seminars.

ELECTRIC UTILITY OPERATIONS

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A Team Approach to Trauma Response Training

FEATURED LINEWORKER
Jason Mendoza
San Diego Gas & Electric

- Enjoys spending time outside in the mountains, desert and beach. He likes to exercise by hiking on the trails, going to the gym or running. He also spends time with his family and attends his kids' sports games and serves as a coach.
- Can't live without a sharp knife, Kleins, a sling rope and his rope access equipment.
- His father worked for Commonwealth Edison and later retired from Exelon after 38 years of service in mechanical maintenance for nuclear generation.
- Married to wife Julie, and they have three sons: 16-year-old Peyton; nine-year-old Christian and five-year-old Samuel.

Serving in the Military

I served six years in the U.S. Navy Seabees with a service combination of active and reserve duty. I served in the construction battalion in the Navy, working on military bases. We had linemen on our crews along with electricians, plumbers, pipefitters and welders. I served as a carpenter builder. During my service, I was deployed to Okinawa, Japan, during peacetime operations. Being in the military teaches you to take direction. Going through apprenticeships gives you that baseline for following orders, paying attention to detail and being there for your brother. The brotherhood in the line trade is similar to that of the military.

Jason Mendoza says as a journeyman lineman, providing power and maintaining service is one of the most rewarding and fulfilling parts of his career.

Early Years

After the military, I moved back to Sterling, Illinois and started working in the utility industry in September 2001 as a meter reader for NICOR Gas in Chicago. In 2006, I moved over to MidAmerican Energy, and that's where I was first exposed to the trade. When I talked to the line crews, I knew it was something I needed to be doing. I went on to complete my apprenticeship and after I topped out as a journeyman, I moved to California to work for San Diego Gas & Electric Co.

Day in the Life

I'm working in the transmission department at SDG&E. My crew is tasked with the maintenance and construction of the transmission grid. We work on anything from pole replacements to tower work, insulator, changeouts and some reconductor work. We also take care of some underground maintenance and construction on the high-voltage side of the house.

Learning New Skills

Since coming to California, I've learned how to work on part of a Human External Cargo team and perform work using a helicopter. I'd never done anything like it before, so it has been cool to be a part of it and go through the extensive training. It's quite a thrill to be on a 100-ft line and go from the ground to the tower or from a tower to a tower to do our work. It's quite a rush, and I love it. I also just completed the 500 kV barehand training qualification. Our move from the Midwest to California allowed me to hone the skills of a West Coast lineman.

Safety Moment

When you're on the barehand live line crew, you have 500,000 V all around you, and you have rigging, sticks, ladders and booms. You must be on your A game and be responsive, alert and pay attention to details and to the safety of everyone involved. It's quite a day to be able to go out there and change V strings or dead ends on an energized line.

Plans for the Future

This is the greatest trade due to the pride, the work and the service to others. I'm planning to keep progressing, keep learning, keep current and bestow my knowledge on to the linemen just beginning in the trade. TDW

Editor's Note: *Thank you to Milwaukee Tools for sending a tool set to the featured linemen.*

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Team Trauma Response Training

Colorado Springs Utilities collaborates with fire, EMS and Flight for Life to provide real-world training for field crews.

By **AMY FISCHBACH**, Field Editor

Line crews often travel far distances and work in remote areas to keep the power flowing for customers. To keep their workers safe in the field, electric utilities often implement an emergency response plan and train their crews in hurtman rescue techniques. Linemen, however, can face a major challenge when waiting for EMS teams to arrive on the scene — especially if they don't have the proper resources, support or equipment.

To protect its field workforce and better equip them to handle emergency situations, Colorado Springs Utilities (CSU) embraced a new approach to hurtman rescue training four years ago. By partnering with local agencies like the Colorado Springs Fire Department (CSFD) and Flight for Life, the utility can provide its electric workers with a more detailed, real-world trauma training program.

Like many other utilities, CSU certified its lineworkers on pole top and vault rescue and basic first aid CPR/AED. To create a more advanced and realistic training program, the utility rolled out a new Enhanced Hurtman Rescue and Trauma Training Program four years ago.

"We knew we needed more advanced lifesaving equipment," said John Rombeck, training and safety specialist for CSU. "If it takes EMS four to eight minutes in town to arrive on scene, we needed to be able to sustain life for at least that long. Our service territory reaches well out of those parameters in Colorado Springs."

Forging Partnerships

Before launching the new program, Rombeck invited his friend, Captain Steve Garcia of the CSFD to take a close look at the First Aid Kits and burn dressing the line crews carried on their trucks.

"The line industry is in desperate need of having the right equipment and items needed to treat the specific injuries that linemen can endure," he said. "We determined we were way under equipped to sustain life for the time we needed to."

Following extensive research, the utility purchased new trauma kits for all line crews, troubleshooters, cable technicians and substation employees. These kits include burn care, torniquets, quick clot gauze, Israeli bandages, C-Collars, and splinting.

After securing the trauma kits, the utility's safety and training team forged a collaborative partnership with the local fire department. The benefits of the training are two-fold — the program not only prepares the utility's electric workers, but it also educates firefighters on how to respond to one of the injured employees.

In addition, the utility incorporated Flight for Life into its Enhanced Hurtman Rescue and Trauma Training program.

Line crews practice applying tourniquets on an injured person on a pole (left). Captain Garcia of CSFD critiques the medical treatment of a line crew's rescue on a transformer pole (right).

Mike Myers, safety and health manager for the utility, built a relationship with the local flight medics. In return, they are willing to train with the utility and support it in any way possible.

By tying all of the aspects of the rescue together, the utility was able to make the training more well-rounded and give the electric employees exposure to how the process really works. It also drives the point home of the importance of working safely.

Through the training session, the participants learn how to activate Flight for Life and discover what parameters are necessary for the pilots to land safely and perform a rescue in the mountains or other remote locations. Crews must be aware of potential landing zones, the location of the nearest fire department or Search and Rescue, the GPS coordinates of their work location and the exact physical address.

Launching the Training Program

Once the utility had the kits, the safety and training team developed a plan to train the employees on how to use the equipment. CSU extended the training from one to two days to incorporate all aspects of the hurtman rescue practices.

The utility, which divides its coverage into North and South areas, provided training for half the workforce at any one time to allow coverage for critical infrastructure and emergency calls. The field workforce including cable technicians, troubleshooters, substation technicians and quality control personnel attended two days of consecutive training.

Four firefighters and EMS personnel also provided service for four hours per week of training. Rombeck said linemen and firefighters have a lot in common, and the interaction in training is invaluable.

Each year, the utility performs a mock rescue and simulates a different life-threatening scenario. For example, a crew performs a pole top or vault rescue and then begins the process of sustaining life until the staged EMS team arrives on scene with lights and sirens.

Over time, the utility designed the training to be more hands-on and interactive. For the trauma training portion, the trainers identified five traumas likely to create loss of life, limb or sight within real-life electrical scenarios. As the crews perform the rescue for all five scenarios, the firefighters and EMS personnel watch the events, provide guidance and offer critiques.

Each crew actively engages in all five stations from the very beginning — from activating EMS to giving and receiving direction from the distribution control center in the event of electrical contact. An actual operator on site is available to help with emergency communications with CSU dispatchers by pressing the orange emergency button on hand-held radios.

During the training sessions, the attendees fill out climbing gear inspection sheets, attend detailed job briefings and then rotate to 11 job stations. Over the course of two days, the employees participate in stations focused on trauma training/emergency radio communication; climbing certification;

basic pole top rescue and transformer pole hurtman rescue. In addition, they rotate through stations including baker board hurtman rescue, baker board certification; bucket self rescue and ground rescue; vault rescue; EPZ grounding; apparatus training and DOT compliance training.

To keep track of the training and certifications for each electrical worker, CSU has expedited the recordkeeping process. The utility once retained paper copies of all the certifications and training before manually inputting the information into a spreadsheet. To streamline the process, Mario Sanchez created an app allowing the trainers to track all the training stations and certification completed by all employees. The app includes times, dates, names, employee numbers and notes for all stations and certifications.

Putting Training into Practice

The first year of the new and improved Enhanced Hurtman Rescue took many hours of brainstorming and planning. After transitioning from his role as a lead lineman to a member of the Training and Safety team, Rombeck partnered with Sanchez and his long-time International Lineman's Rodeo teammates, Tyler Dimenza and Cody Strong, to prepare to train 100 electric workers on life-saving measures in two different two-day training sessions.

"Multiple people from the crews assisted with the preparations as well as with the training itself," he said. "Many others invested countless hours into the details and preparation of the training. We knew we had one shot at getting this right, or we would lose interest from management as well as the linemen."

The electrical workers' engagement in the trauma response training exceeded expectations. Both experienced linemen and brand-new apprentices were asking questions, volunteering and actively engaged throughout the whole process.

The safety and training team leveraged the feedback to continue to make the training process smoother, better and more engaging. By adding multiple layers and scenarios to the training, each participant now has the opportunity to perform a rescue and hone skills.

"Apprentices don't get proficient at climbing poles by doing it one time every year," Rombeck said. "They get proficient by seeing it, then trying it and then practicing what they've learned. Line work is ever evolving, and we are continually striving for improvement to include how we will respond to the worst-case scenarios."

CSU is continuously looking for ways to improve its rescue training and continue to protect its field workforce. By implementing a detailed emergency response plan and training at a high level on life-saving measures, the line crews can save time in an actual emergency. TDW

AMY FISCHBACH (*amyfischbach@gmail.com*) is the Field Editor for Transmission & Distribution World magazine.

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Parting Shot

Photo by **DAN RABERN** of CORE

Kris Onda, an apprentice for CORE Electric Cooperative, repairs a broken insulator during a snowstorm to get the power back on in Conifer, Colorado.

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An overhead line worker for Dominion. As part of its undergrounding program, Dominion studied which of its overhead lines were the most outage prone.
Photo by Dominion Energy.

Dominion Undergrounds 1800 Miles and Counting

Dominion Energy replaces its most outage-prone overhead electric distribution lines with cost-effective underground lines.

By **HEATHER MONTVILLE** and **JULIA MATHERS**, Dominion Energy

Fewer things in life are more frustrating than being without electricity. When the power is out, lives are halted. People cannot access the internet, charge their cell phones, heat or cool their homes, or even prepare meals. Almost every aspect of life is reliant on electricity.

Nearly 1 million customers of Dominion Energy experienced how true this is on June 29, 2012, when a straight-line wind thunderstorm swept through the utility's service area and knocked out their power. It took more than eight days and thousands of employees and contractor resources to restore power.

In the following days, Dominion examined the data and number of overhead lines that service its customers. The utility discovered a common element: tap lines that are the most outage prone. If it could put a percentage of these lines underground, power could be restored more quickly. Customers could get back to their lives faster and reliability could be improved. With this in mind, the utility's strategic underground program (SUP) was born.

All About SUP

Dominion's SUP is a reliability initiative aimed at replacing the most outage-prone overhead electric distribution lines with cost-effective underground lines. Burying these tap lines, which serve neighborhoods and homes, reduces the number of repairs needed for service restoration following a major storm. This benefits all customers, even those whose lines remain overhead. Why? Because there are fewer lines to repair and fewer repairs to individual properties, enabling line crews to focus on other outages, so power can be restored more quickly for everyone.

The SUP team analyzes 10 years of outage data to determine which tap lines are the most prone to outages. These tap line candidates are researched by the team to determine if they should be placed underground. Technical coordinators, such as Dominion's Randy Ennis, assess the existing poles and transformers and create an initial plan for where new underground facilities should go.

"After I determine a tap line meets our requirements of outage events per mile, making it a qualifying tap, a field visit is done to investigate the line further," Ennis said. "One of the things I am looking for is constructability. Does the terrain provide us the access we need to set up and use our drilling equipment, and will the terrain allow us the space to safely install and

Dominion staff talk about utility work with residential property owners. It can take many months as Dominion works to obtain easements, educate customers, and install the underground cable and equipment. Photo by Dominion Energy.

and maintain our underground and aboveground facilities?"

Ennis continued, "Over the years, I have been very impressed with what our crews and their equipment have been able to accomplish. Furthermore, by using Dominion's award-winning augmented reality application, the customer can even visualize what a padmounted transformer or pedestal would look like on their property!"

Dominion's crews perform the undergrounding work through directional drilling and potholing. When underground construction is complete, they perform pole topping.

Directional Drilling

Directional drills are used rather than open trenching to minimize disruption to landscaping. SUP teams work with property owners to determine an acceptable placement of underground facilities.

This type of drill provides a low-impact way to install conduit and cables horizontally underground. A construction hole is used as an entrance point for the drill, which can travel up to 500 ft (152 m) from the single entrance hole. To ensure safe installation of the underground lines, crews work with one-call underground

A field crew member works on an underground distribution line. Technical coordinators assess existing poles and transformers and create an initial plan for where new underground facilities should go. Photo by Dominion Energy.

(Inset) A worker uses a handheld underground utility locating system to check before digging. Dominion crews perform undergrounding work through directional drilling and potholing. Photo by Dominion Energy.

Underground lines come into a ground-level padmounted transformer from below, where connections are locked safely inside and out of view. Photo by Dominion Energy.

damage prevention services, to identify any underground public utilities (that is, water, sewer and gas).

Potholing

In cases where the underground cable will cross other utilities, smaller safety holes are hand dug. This practice, a term called "potholing," is required because the safety holes expose the other underground utilities and ensure the drill has enough clearance to pull the new underground electric cable through safely.

In a recent Dominion podcast, which focuses solely on the program, the utility's Director of Grid Resiliency Steve Eisenrauch, talked about the drilling process: "While there's still some opportunities for injury and damage to other underground facilities, this method is definitely superior to trenching, as there is much less disturbed earth, sidewalk, and driveways that could present tripping and falling hazards."

Underground lines come into a ground-level padmounted transformer from below, where connections are locked safely inside and out of view. The installation of these underground electric lines adheres to the requirements of the National Electrical Safety Code (NESC). Lines are buried approximately 36 inches to 48 inches (914 mm to 1219 mm) below the surface, so they are below tree roots and the frost line.

The location of each padmounted transformer is determined by the electric load calculations and route of the underground lines. In some cases, a meter base adapter is needed at the customer's home to accept cables from underground.

Effective Planning

The time required to complete an individual undergrounding project can vary based on many factors. In the case of a large subdivision project, it can take many months as Dominion works to obtain easements, educate customers, and install the underground cable and equipment. In the case of smaller communities, work potentially can be completed more quickly.

Property owners and neighborhood organizations are advised of what to expect when a project is planned. This

is a long-term process, and extra measures are taken to ensure impacts to properties are mitigated as much as possible.

Property owners are notified in advance when an outage is scheduled to make any necessary adjustments. An outage to make the final conversion from overhead service to underground service typically lasts four hours or less, and power supply equipment is offered to customers who express a need to stay connected during that time.

Pole Topping

Once all underground construction is complete and the new lines are connected at pedestals, Dominion removes any overhead electric lines and equipment from the poles. Dominion also may top the pole, meaning crews will remove unneeded pole height. This decision is determined by the owner of the pole going forward.

If Dominion remains the pole owner, then the unneeded pole height will be removed. If a telecommunications company becomes the pole owner, Dominion defers to the new pole owner on whether to remove any unneeded pole height. The new pole owner applies their standards to ensure safe and effective operation of the pole line.

Bottom Line

During the last five years, more than 1800 miles (2897 km) of overhead tap lines have been converted to underground through the SUP. Because the program is spread so extensively throughout Dominion's service area, both Dominion and contract employees are involved in all aspects of the program, including project management, design, right-of-way, communications, installation, removal of equipment and property restoration. Additionally, each project has a dedicated Dominion point of contact.

Dominion continues to focus on undergrounding the most outage-prone overhead tap lines within its service area. The utility is proud to give more peace of mind to its customers, so that when a major storm hits, they can enjoy faster restoration times and, in some cases, no outage at all. TDW

HEATHER MONTVILLE is communications manager for Dominion Energy's strategic underground program (SUP), developing and overseeing the program's award-winning communication efforts within the utility's Virginia and North Carolina service territories. Customer communication is the backbone of SUP. Montville and her team are constantly looking for new and innovative ways to improve the process as the program continues to grow. With a bachelor's degree in business and a master's degree in marketing, Montville finds excitement in diving into new opportunities to create innovative processes in this ever-expanding program.

JULIA MATHERS (*julia.e.mathers@dominionenergy.com*) is a marketing and communications coordinator for the strategic underground program (SUP), with 15 years of energy experience working within the Dominion Energy Virginia Distribution organization. As part of the SUP, Mathers partners with the utility's authorized construction contractors to give an organic customer service experience. By using the program's augmented reality app, Mathers can give customer a visual of how the new underground facilities will look in their yard. Mather's bachelor's degree in English has inspired her to communicate with customers whether it be written, verbal or just through a smile.

A Mobile Future

PNMR explores adding mobile reporting functionality to its safety management system, including key requirements, vendors, benefits and challenges.

By **NELS HOENIG**, PNM Resources

Most hours of work at an electric utility happen in the field, away from a desk and PC. For this reason, utilities should consider a mobile solution to report issues where they happen and when they happen.

PNM Resources, a mid-sized electric utility serving customers in New Mexico and Texas, currently uses a server-based safety management system (SMS) to manage incidents. As the SMS is used daily by many in PNMR's workforce, the utility wanted to make a good solution even better by adding mobile functionality. In 2022, it kicked off Project Blue Snow to find a solution that could help it to prepare for the future of SMS reporting.

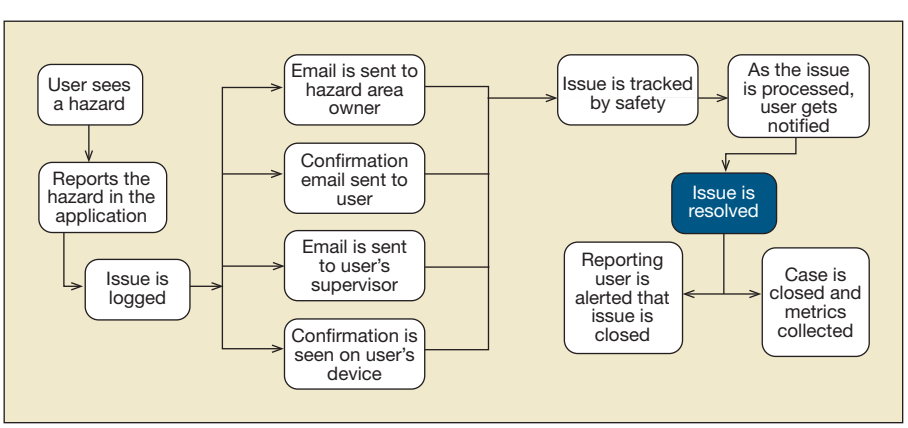
Refining Requirements

In looking at the concept of a mobile reporting solution, the project team talked to the utility's various business operations about their needs and wants to determine requirements. This task ended up being quite challenging. Many people had trouble explaining what they wanted, as they were not used to being asked for their input but rather being told what they would get. Others offered many ideas about what should be done.

The project team refined this input into requirements it felt could be accomplished within a limited budget, from both a time and money standpoint. Overall, the solution needed to be accessible to employees (including office workers) on common mobile devices and PCs; intuitive to use on day one, without the need for a lot of training; available 24/7, even when there is no internet connection; and secure using two-factor authentication, to ensure only authorized workers can access the solution when creating new records or viewing existing records.

In addition, from a specific features standpoint, the project team identified these requirements:

- **Geotagging** — Make it possible to drop a tag to detail exactly



Mobile hazard workflow.

where an issue is located, as many locations do not have a street address.

- **Flexibility —** Provide plenty of text space to capture notes and even the ability to dictate notes.
- **Photos —** Allow multiple photos to be added to a record and enable editing or marking up the photos within the application to better document the concern.
- **Drop-Down Lists —** Make the tool fast to use and the data consistent in reporting by providing preloaded drop-down choices, with the ability to add new values.
- **Form Based —** Provide preloaded forms with questions and information presented in a logical and consistent way.
- **Easy to customize —** Have the ability to design custom forms, with custom drop-down lists and workflows. PNM needs a system that nontechnical people can update and expand.
- **Connectivity —** Interface with email and potentially instant messaging applications, so updates can be shared quickly.

In addition to these features, the solution needed to be modular, so PNMR could do a phased implementation. This new project is a bit of an experiment, so costs are being monitored closely because the return on investment is speculative.

PNMR Plans

In its research, PNMR found mobile SMS is a growing marketplace. It used G2 to find and evaluate vendors. The utility found more than 100 vendors with solutions in this market space. Located all around the world, these vendors are at different levels of business maturity.

PNMR found that multiple vendors offer solutions that would meet many of its business needs, though the vendors often had different ways of solving those needs. The project team engaged in several demos and even had an opportunity to test generic applications on their mobile devices. This process enabled the utility to understand what it needs and what design choices ultimately would provide the optimal solution.

However, the utility is not in a position to replace its SMS solution today. Rather, it plans to start by deploying the mobile solution to do very specific tasks that cannot be done as effectively today. The utility's long-term goal is to move to a single comprehensive SMS solution that includes support for remote users.

Reporting Hazards

PNMR's first area of focus is improving the process to report hazards as they are found. Process improvements in this area will give the utility added visibility to a hazard in real time and better tracking for data analysis. For this effort, a hazard is defined as "any company-managed asset that has an increased level of risk to cause damage to health, life, property or any other interest of value." A company-managed asset includes utility poles, company locations, vehicles and transmission equipment, for example. By proactively addressing hazards, PNMR hopes to increase awareness of workplace hazards and, ultimately, create a safer workplace and community.

By using a mobile solution, PNMR anticipates an increase in

Workplace hazards: Messy offices can be worse than simply disorganized. They can endanger people who work in them. Hazardous wiring or broken light bulbs are a potential threat for an indoor or office environment. A less obvious safety hazard, such as exposed rebar that could trip someone, can also be catalogued. Photos by PNM Resources.

the number of hazards reported, which will enable the utility to resolve them before injuries or outages occur. The reporting form was intentionally designed to be simple to complete and includes geotagging, photos and talk to text. The user can do all the actions from a mobile device and submitted forms are saved to a cloud storage system, which triggers email alerts. PNMR designed a simple workflow for this process.

A Few Challenges

Change is hard and the project team recognizes there are a few challenges with this solution.

For one, the utility has a mature workforce, and changing a process is not a simple matter. The project team has numerous ideas to get employees interested in the new application, but the team does expect younger workers to adopt the technology more quickly.

This tornado-damaged power distribution equipment is another hazard that can be tracked using the mobile safety system. Photo by PNM Resources.

This disorganized bucket truck represents several potential hazards to workers.

Another challenge is the need to support two solutions. This is a big concern, but the utility has a plan. IT will continue to support the existing SMS solution and the Safety department has committed to supporting the mobile portion. (another reason why the mobile solution must be easy to support, even for nontechnical employees).

Interfaces to HR for employee access management and the email solution must be built and tested. Fortunately, the utility's IT team has cloud experience in this area.

Another challenge the project team must overcome is employee resistance to adding a company application on personal devices (about 50% of employees have company-owned devices). The project team cannot force users to install the app, so it is planning a promotion of incentives to get employees excited. While not monetary, small gifts have proven highly successful in getting the business engaged.

Finally, potential union contract issues are a possibility. Any time work processes change, existing union agreements must be reviewed and potentially revised.

Despite these challenges, PNMR recognizes the need to prepare for the future and believes a mobile solution is critical to its continued success. Focusing on a subset of the SMS solution enables the utility to learn the solution at a reduced cost and risk. This approach is important because PNMR, as a regulated utility, monitors its costs carefully.

Building an Understanding

Today's workforce uses cell phones in all aspects of their lives. PNMR sees incorporating a mobile reporting solution as a way to take advantage of this reality. Mobile use continues to grow. As with customers who expect to be able to access their account

and do other tasks on a mobile device, employee demand for mobile functionality in utility operations will continue to grow.

PNMR has a major grid modernization program underway, so it needs to adapt its Safety department to a changing, distributed way of serving customers. Supporting the mobile application is one way Safety is making this transition.

By focusing first on hazard reporting, this allows time for the project team to identify challenges that will need to be addressed with a full replacement. PNMR did an SMS replacement several years ago that was not well received, so it will need to do a better job the next time.

In addition, the utility will continue to build an understanding of mobile safety solutions and what it truly needs. Employees are talking more and more about digital tailboards and incident reporting. The utility must be able to support these kinds of changes, and the hazard reporting module is a good first step.

PNMR expects to see an immediate payback for hazards through improved visibility and reduced outages due to preventive problem resolution. Once the hazard reporting module is live, the utility plans to roll out additional functionality. TDW

PNMR's new system reports hazards as they are found. This could include an obvious hazard like a tree contacting a power line, or a less obvious threat. Photo by PNM Resources.

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—Ahad Esmaeilian, Chair, IEEE PES Grid Edge Technologies Conference & Exposition.

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BY KELLY BRODBECK, TELEDYNE FLIR

Inspecting T&D towers and lines comes with added risk to crews, and the process can become complex when trying to get accurate measurements. Photo by Lone Star Drones.

Thermal Drones Gain Traction in T&D Inspections

Today's advanced drones and thermal camera systems provide multidimensional benefits to electric power utilities of every size.

Thermal cameras have played a critical role in electrical utility preventative maintenance programs for decades. Getting accurate, noncontact temperature measurements of energized equipment enables crews to detect anomalies, track failures over time and properly prioritize repair efforts, while also maintaining the safety of inspection personnel.

Inspecting T&D towers and lines comes with added risk to crews, and the process can become complex when trying to get accurate measurements. Recently, thermal-equipped drones have gained traction as an effective tool for safely and efficiently inspecting T&D lines as well as their poles and towers — essentially every element of the power generation, transmission and distribution system. Standing up a drone program to inspect T&D infrastructure keeps crews safely on the ground and away from energized equipment, while also enabling them to complete inspections in a fraction of the time required for more traditional methods.

Crews can immediately assess equipment maintenance and replacement needs while keeping a safe distance. Then, once the inspection is complete, maintenance can begin to correct potential issues before a full breakdown causes a service disruption, saving time, money and customer frustration by identifying and fixing issues before they become failures.

"Utilities are using drones for lots of T&D applications," said David Lee, a Level III thermographer and longtime commercial drone pilot. "They can find the small temperature differences that could turn into big problems without putting crews in helicopters or up the towers, and they can reach multiple towers from a single point of deployment, saving lots of time."

Of course, using a thermal imaging-equipped drone for routine inspection is not as simple as flying a drone to the area of interest and capturing imagery. It requires specialized training to learn how to use the equipment most effectively while maintaining regulatory compliance. In addition, until recently, drone thermal inspections have had some practical limitations — data accuracy, flexibility and security among them — that are now being solved.

The Necessary Data

While drone inspections still are more efficient than manual inspections, the thermal sensors used on drones have not been optimized for taking quantitative temperature measurements the way handheld thermal cameras are, limiting them to more of a qualitative thermal-screening tool.

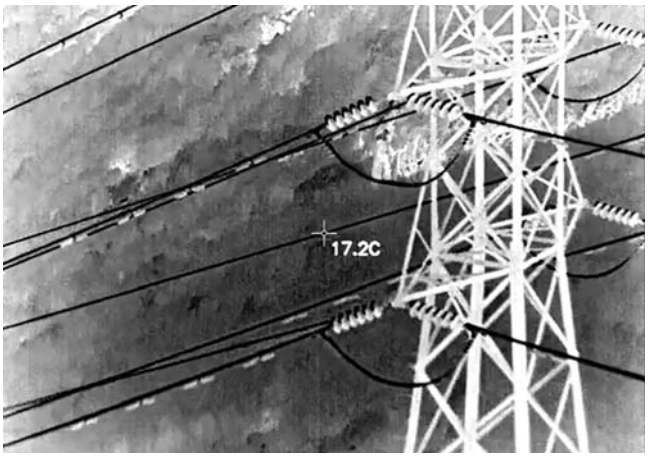
These two basic types of thermographic inspections — quantitative and qualitative — come down to whether the operator needs to get an accurate temperature measurement or just needs to find hot spots. One of the key factors required to get an accurate qualitative measurement is having enough pixels on target.

"To take an accurate, quantitative infrared measurement, you need to satisfy the camera's spot size ratio," Lee noted. "It's vitally important to getting an accurate measurement because it's one of the few things you can't change in the software — either you've got enough pixels on target or you don't and you have to retake the image."

For a variety of reasons, thermographic cameras cannot get a reliable measurement from a single pixel; they need a collection of them. How many pixels varies depending on the camera model, but on the Teledyne FLIR SIRAS, for example, it is a square of multiple pixels.

Dedicated thermography cameras have a reticle displayed on the screen that shows the square of pixels required to attain an accurate measurement. When the target fills the reticle, it is close enough to the camera to capture an accurate measurement. In the past, drone thermal cameras have been missing this vital piece of information, requiring operators to guess how close they need to get to their target and when they have achieved that distance. Modern platforms can provide that information in flight to attain more accurate measurements.

"Having a visible representation of your spot size relative to your target in real time on a drone is a game changer, and really helps make SIRAS a quantitative measurement drone platform," Lee explained. "Many drones have a crosshair representing a single pixel, but it's not providing an accurate temperature measurement."

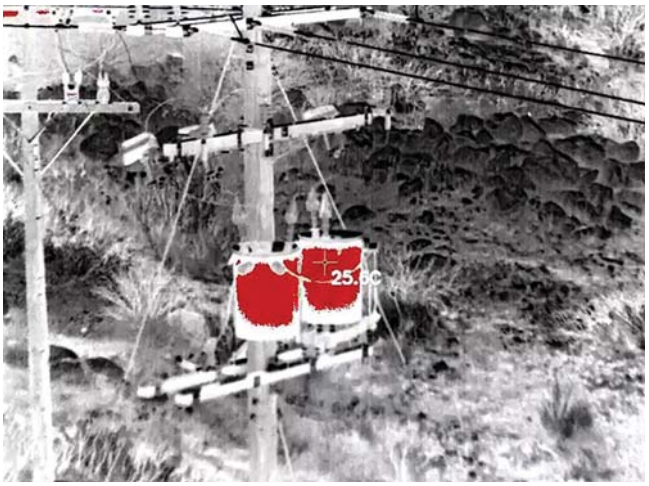


Recently, thermal-equipped drones have gained traction as an effective tool for safely and efficiently inspecting T&D lines as well as their poles and towers. Photo by Teledyne FLIR.

This method can rapidly improve efficiency, as it eliminates the need for additional crew members to quantify the severity of a given problem through other more traditional methods, all while improving safety.

When And Where

One of the major challenges of inspecting critical infrastructure, like utility assets, is securing the technology, training and



Until recently, drone thermal inspections have had some practical limitations — data accuracy, flexibility and security among them — that are now being solved. Photo by Teledyne FLIR.

Utility infrastructure inspection can be more efficient utilizing drones equipped with multispectral imaging capabilities, especially a combination of thermal and visible imagery, via a process called MSX. Photo by Lone Star Drones.

regulatory approval to easily inspect such sensitive infrastructure. Regulators face a challenging dilemma in terms of safely and efficiently integrating unmanned aircraft system (UAS) operations into their respective national airspace systems and enforcing compliance with relevant regulations, including the enforcement of no-fly zones around sensitive areas, such as utility infrastructure.

Many drone manufacturers created geo-fencing systems to keep their drones from flying in sensitive places, from airports to power plants. Geo-fencing uses the drone's GPS location to determine whether it is inside a geo-fenced area and locks the pilot out from flying if the drone is determined to be in an unauthorized location. While geo-fencing seems like a good idea on the surface, it creates complications and challenges for utility operators. Power generation, transmission and distribution facilities often are considered critical infrastructure and can be included in a drone's geo-fenced restrictions. These geo-fences apply to everyone equally — even the utility operators who need to inspect these components to keep the power grid functioning. Those same utilities often must secure additional approval to simply fly within their own geographical footprint.

Allowing operators to fly when and where the mission demands is critical to utility operations. The new SIRAS does not use geo-fencing. Professional drone pilots can fly without the added complication of the drone's firmware keeping them on the ground because the manufacturer assumes the pilot is not authorized to fly in certain locations. It also places the responsibility to fly in legal airspace with the pilot. This enables utility drone pilots to inspect the towers and components they need to — especially critical during an emergency when seconds and minutes matter.

In support of such efforts, the U.S. House of Representatives recently passed a bipartisan bill to help state, local and tribal governments use drones to visually inspect critical infrastructure. H.R. 5315, the Drone Infrastructure Inspection Grant Act, would provide US$100 million in grants for local governments to purchase drones or contract for services to inspect critical infrastructure and help to ease the nation's serious inspection backlog. Another $100 million is earmarked for training the next-generation workforce on the use of this technology. A companion bill in the U.S. Senate also is under consideration to help convert the legislation into law.

Providing Data Privacy

In the interest of national security, industrial drones also are doing away with cloud data connections, reducing the entry points for would-be hackers to access sensitive data about utilities, such as a nuclear power plant or critical substation.

Drones like the Teledyne FLIR SIRAS maintain data privacy by only storing data to an on-board SD card, so pilots do not have to worry about data being sent to other places or organizations without their knowledge. By not including transmission capabilities other than the necessary control and video signals sent between the airframe and the controller (or to comply with the Federal Aviation Administration's Remote ID rules), utilities and inspectors can have peace of mind that data will be more secure.

A New Era

Thanks to advances in technology and policy, along with a renewed focus on data privacy and security, leveraging thermal-equipped drones for completing critical utility inspections is more viable than ever before.

Improved equipment capabilities reduce inspection time while improving safety. In turn, industrial-grade drones also are making the use of drones for utility inspection easier to operate while providing improved data privacy. Meanwhile, governments around the world, including the U.S. federal government, recognize the value of drone-based critical infrastructure inspection for national interests. They are providing more resources and funds to encourage the use of drones today and for generations to come.

For utilities that have not explored drone thermal inspections yet, now is the time. TDW

KELLY BRODBECK is a product management executive with experience in multiple technical industries including thermal imaging, photonics, energy development and operations, and medical device. He is currently charged with advancing Teledyne FLIRs commercial UAS product offerings to serve a broader portion of the market with new payloads, airframes, and software.

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A Collaborative DER Registry: Solving a Big Problem the Right Way

It is undisputable that distributed energy resources (DERs) are having a significant impact on our industry. While the impact of DERs can be positive, especially for the individual consumer, their impacts to the grid at large are not always positive. Over the past several years, our team has had the privilege to work around the world in places like Australia, Ireland, Germany and many others. We have had the opportunity to see firsthand the challenges of transitioning a grid to higher penetrations of DERs, examining what has and has not worked. We then went one step further and asked what would make a difference for our entire industry.The answer is a collaborative CIM-based DER Registry. Why? Because a common set of data can be shared among the consumer, distribution utility, transmission utility/ISO, market, regulators, and competitive suppliers to allow DERs to help solve grid problems instead of creating them. The data must be secure, allow seamless integration to existing utility and market systems by using CIM data structures, and allow each regulatory authority to determine who has access to the different data elements. Most importantly, it must be cost-effective so all stakeholders in the energy value chain can participate effectively. But how?

About 30 years ago, EPRI started an initiative that became the Common Information Model (CIM) for the electric industry for large-scale generators, a common way to take the operational and market data necessary for any generator to connect to the grid. CIM saved billions of dollars by setting this 'lingua franca' or 'translator' to ensure every machine, regardless of origin, could speak the language of the grid without having to create a custom interface. Today, we stand at a similar doorway, but this time it's not about a few thousand machines; it's about millions. The cost and coordination implications are immense, and entire countries/markets are struggling because they did not address this issue before reaching significant penetrations of DERs. The lessons have already been learned, and we must act to recognize this new resource and work collaboratively to effectively incorporate DERs.

Creating such a system could be a lucrative venture for the IT industry. Or it could be built as an enabling tool for the utility industry to help DERs become a useful part of our grid and markets at the lowest cost possible. We chose the latter and have created a non-profit company, Collaborative Utility Solutions (CUS), that will serve the industry in a collaborative manner at the lowest possible cost and give the proverbial "reins" to our industry membership to guide and direct all future advancement. We have taken the first steps, and today we are excited to make this system available to the industry: *www.cusln.org*.

Starting today, every U.S. utility immediately has free access to the electronic data collection and management of DER information. We understand many utilities are still using paper systems or excel spreadsheets to collect DER interconnection information, and we want to provide them an electronic alternative immediately. Over time, if they choose to become a member, they gain access to the mapping, analytics, API/date exchanges, and historical information upload included in the DER registry and become a governing/voting member for all changes going forward. ISOs and regulatory agencies will have access at no cost.

The first question we often get is, "What's the catch?" As we are a non-profit, the finances are open-book, and the by-laws and operating agreement are given to members. The members are the stakeholders for DERs: regulators, ISOs, utilities, consumers, equipment suppliers and aggregators. The members, with the board, are the sole authority to guide the future of the registry. This ensures the necessary transparency and fair access to the data with the proper regulatory oversight and security. The non-profit structure also delivers this necessary tool for the industry at a small fraction of the cost of competitive solutions and an ever-decreasing cost for each member as more participate. Perhaps most importantly, members are in control of the future of the DER Registry.

The next question is, "Seems a bit self-evident, why don't you just move forward?" Unfortunately, the electricity industry has spent the last several decades fragmenting and creating unique silos — Disco/EDC, Transco/RTO/ISO, GenCo/IPP, Vertically Integrated or Competitive choice. The continuous fragmentation has created a mammoth opportunity for some to take advantage of our industry through this fragmentation, and individual industry participants have a limited focus on the holistic energy picture. We know that the electric industry flourished when we collaborated on best practices of design, operation, and education. We know that standards drive efficiency and market effectiveness. We know data sharing drives lower cost and overall effectiveness. However, our fragmentation and silo thinking make it a challenge for us individually in our day-to-day role to support broader decisions. The mission of CUS is to enable collaboration among the various silos necessary to make DERs benefit the grid and markets holistically.

Does this make us and our effort analogous to Don Quixote? Well, the simplest answer is, it doesn't matter. The right question is how we all can work together to make DERs work? It is an exciting time to be in the electric industry. We are thankful to have had the opportunity to work with such a broad cross-section of our industry in the past few years to create the non-profit DER Registry.

We present it now to help our industry effectively implement DERs and support grids around the world to effectively enable DERs. We want to thank everyone who has supported this initiative, with a special recognition to Esri for its support. We look forward to working with our industry for a cleaner, more reliable, and efficient future with DERs making a positive contribution to grid reliability. TDW

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